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SYSTOLIC EMULATOR EXPERIMENTATION

Richard N. Smith and Michael W. Fenton

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Rome Air Development Center
Air Force Systems Command
Griffiss Air Force Base, NY 13441-5700

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APPROVED:

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Communications Transmission Division
Directorate of Communications

APPROVED:

JOHN A. GRANIERO
Technical Director
Directorate of Communications

FOR THE COMMANDER:

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Richard N. Smith and Michael W. Fenton

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13. ABSTRACT (Maximum 200 words)

Adaptive spatial filtering or adaptive antenna nulling techniques have been used to remove or eliminate directional electromagnetic interferences or unwanted signals from getting into radio receivers. This signal processing technique has been studied for many years. Many systems have been proposed, some have been built and a few have been fielded.

High speed parallel processors are beginning to show promise in providing real-time solutions for meeting the processing requirements needed for space applications. One type of high speed parallel processor architecture is called systolic. The name arises from the way the data pulses through the cell-like structure of the processor in a prescribed pipelined manner. Effective implementation of adaptive signal processing techniques using systolic array processors, especially, required careful matching between the algorithm to be performed and the processor architecture. This

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process of matching algorithm and architecture can be facilitated by computer emulation.

This report will describe the process of designing, emulating, and testing two adaptive antenna nulling processors. The processors were designed to be part of a three-element adaptive antenna sidelobe canceller system. Using this system, the signals to two elements are appropriately weighted, and their sum is then subtracted from the reference signal to remove interference. After the processors were designed and emulated, they were tested using artificial data and simulated data obtained from an emulated three-element antenna array system. The performance of each processor was then evaluated using residue and antenna gain pattern plots.

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I. Introduction

This work was done under Task 2 of the "Communications Adaptive Array Processor Evaluation" In-House project #45194263. The objective of this task was to employ two computer software tools to explore the interrelationships between adaptive antenna algorithms and systolic processors. The two software tools, EMUL and GADAR[1], were delivered by the Hazeltine Corp. under the "Systolic Array Processor Brassboard" project #45194248. The EMUL software tool is designed for the emulation of various systolic array processor architectures. Each processor architecture is designed to specifically implement a single algorithm such that the algorithm may be processed efficiently. The GADAR software tool allows the generation of simulated signals for the purpose of testing processor performance. Due to the lack of comprehensive documentation of these tools, this report may also serve as a guide to the use of EMUL and GADAR.

Adaptive spatial filtering or adaptive antenna nulling techniques have been used to remove or eliminate directional electromagnetic interferences or unwanted signals from getting into radio receivers. This signal processing technique has been studied for many years. Many systems have been proposed, some have been built and a few have been fielded.

High speed parallel processors are beginning to show promise in providing real time solutions for meeting the

processing requirements needed for space applications. One type of high speed parallel processor architecture is called systolic. The name arises from the way the data pulses through the cell-like structure of the processor in a prescribed pipelined manner. Effective implementation of adaptive signal processing techniques using systolic array processors, especially, requires careful matching between the algorithm to be performed and the processor architecture. This process of matching algorithm and architecture can be facilitated by computer emulation.

This report will describe the process of designing, emulating and testing two adaptive antenna nulling processors. The processors were designed to be part of a three-element adaptive antenna sidelobe canceller system [2] (see Figure 1). Using this system, the signals to two elements are appropriately weighted, and their sum is then subtracted from the reference signal to remove interference. After the processors were designed and emulated, they were tested using artificial data and simulated data obtained from an emulated three element antenna array system. The performance of each processor was then evaluated using residue and antenna gain pattern plots.

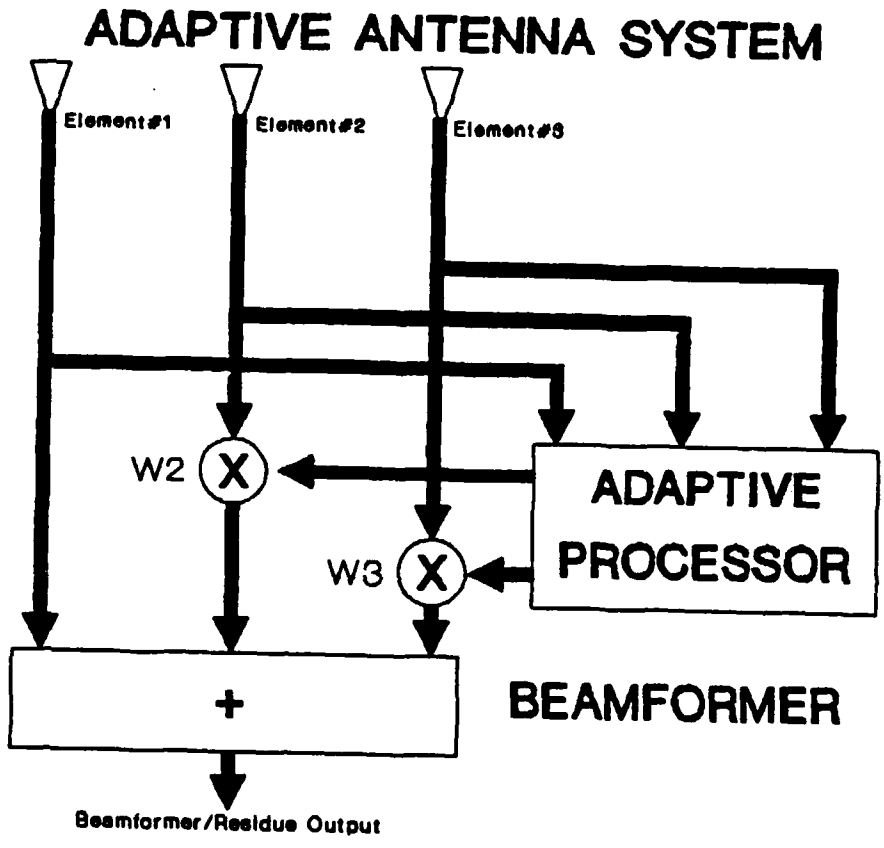

Figure 1

II Algorithms

2.1 Adaptive Spatial Filtering

A three element adaptive antenna system is shown in Figure 1. This system is configured as a side lobe canceller[2]. Antenna elements #2 and #3 are weighted and combined with element #1 in the beamformer. The beamformed/residue output is

used as an input for a conventional receiver. Based on the signals received from the three antenna elements the adaptive processor computes the weights that are to be applied to antenna elements #2 and #3. The weights adjust the amplitude and phase of elements #2 and #3, so that when all the signals are combined in the beamformer, the output power of the interference signal will be minimized. This interference suppression technique is sometimes referred to as spatial filtering because it suppresses interference based on a spatial discriminate.

2.2 Sample Matrix Inversion (SMI)

The SMI algorithm is primarily a block data algorithm. This means that M array snapshots are collected and then processed to compute a weight set. A snapshot is defined to be a sample from each antenna element at one specific time. This process is repeated to compute subsequent weight sets. The number of required snapshots, M, is at least 2N where N is the number of adaptive elements. The choice of 2N samples insures that, providing that there is no desired signal present, the weights computed will provide a solution that is within 3db of an optimum solution [2].

The SMI algorithm solves the system of equations (matrix equation) shown in Equation 1.

$$Ax=b \qquad (1)$$

In this equation, A is referred to as the data matrix and contains 2N snapshots from each of the weighted antenna elements. The vector x is referred to as the weight vector and will contain N weights. The vector b is called the reference vector and contains 2N snapshots of the reference element. To solve this system of equations we proceed by multiplying both sides of Equation 1 by the Hermitian transpose of the data matrix A as shown in Equation 2.

$$A^{H}Ax=A^{H}b \qquad (2)$$

Now the system is a square system of equations and the solution can be obtained by multiplying both sides by the inverse of the matrix $(A^{H}A)$ as shown in Equation 3.

$$(A^{H}A)^{-1}(A^{H}A)x=(A^{H}A)^{-1}A^{H}b \qquad (3)$$

Equation 3 can be rewritten as shown in Equation 4.

$$x=(A^{H}A)^{-1}A^{H}b \qquad (4)$$

The vector x contains the weight/solution vector that will satisfy the original system of equations.

2.3 Unitary Transformations (Givin's Method)

The following discussion is based on an RADC final report written by ESL entitled "High Speed Adaptive Signal Processing"[3]. The algorithm, called Givin's Method, is a method of solving a system of linear equations that is formed from sampled signals taken from an adaptive array. The adaptive array takes samples of the same signal that are spatially or time separated, causing them to differ slightly in amplitude and phase. One of these samples is used as a reference, and an estimate of the reference is made by taking a linear combination of the rest of the samples. This estimate is subtracted from the reference to cancel out any high power interference. A system of equations must be solved to determine the weights that each of the samples must be multiplied by. The system of equations is of the form, Aw=b, where A is an m x n matrix comprised of the m snapshots of the signal sampled at each of the n antenna elements, w is an n element weight column vector, and b is the m element reference column vector.

An example using three antenna elements and four snapshots is used to demonstrate Givin's Method. The system of equations to be solved looks like this:

$$\begin{bmatrix} A11 & A12 \\ A21 & A22 \\ A31 & A32 \\ A41 & A42 \end{bmatrix} \begin{bmatrix} w1 \\ w2 \end{bmatrix} = \begin{bmatrix} b1 \\ b2 \\ b3 \\ b4 \end{bmatrix}$$

The columns of A represent the two nonreference antennae, and the rows represent the four snapshots taken at each. The w values are the unknown weights and the b values are the values of the four snapshots of the signal at the reference antenna.

The goal of Givin's method is to multiply the system of equations by some unitary transformation matrix that will result in a system of equations that is easy to solve. Factoring the A matrix into some matrix Q and an upper triangular matrix U gives the equation:

$$QUw=b$$

Q is defined to be a unitary matrix so that

$$Q^{H}=Q^{-1}$$

where Q^{H} is the Hermitian transpose of Q. Multiplying both sides of the equation by this gives

$$Q^{H}QUw=Q^{H}b$$

$$\text{and} \quad Uw=Q^{H}b$$

With the weight vector being multiplied by an upper triangular matrix, this equation is very simple to solve. $Q^{H}b$ must be solved first, and then a simple backsolve will give the weight vector. Q^{H} is the unitary transformation matrix that is

needed. Givin's method does not calculate this matrix specifically, but it applies a series of two by two matrices to the A matrix, which has the same effect of producing the upper triangular matrix. Since the Q^H vector must be applied to b as well as to A, it is convenient to form a new matrix having n + 1 columns that combines the two. The new matrix will be in the form

$$\bar{A} = \begin{bmatrix} A11 & A12 & b1 \\ A21 & A22 & b2 \\ A31 & A32 & b3 \\ A41 & A42 & b4 \end{bmatrix}$$

The algorithm applies what are called Givin's rotations. It calculates a two by two matrix defined to be

$$M = \begin{bmatrix} c & s \\ -s & c \end{bmatrix}$$

where

$$c = x^*/r$$

$$s = n/r$$

$$r = (n^2 + |x|^2)^{1/2}$$

where n is a real number, x is complex, and x^* is the complex conjugate of x. It assigns entries from the same column and in adjacent rows of the $\bar{A}$ matrix to x and n starting with the lower left corner. This would be in the form

$$\bar{A} = \begin{bmatrix} A11 & A12 & b1 \\ A21 & A22 & b2 \\ x & A32 & b3 \\ n & A42 & b4 \end{bmatrix}$$

Since n has to be a real number, a row of zeroes is added to form

$$\bar{A} = \begin{bmatrix} A11 & A12 & b1 \\ A21 & A22 & b2 \\ A31 & A32 & b3 \\ x & A42 & b4 \\ n & 0 & 0 \end{bmatrix}$$

The M matrix is then formed and multiplies the bottom two rows resulting in

$$\bar{A} = \begin{bmatrix} A11 & A12 & b1 \\ A21 & A22 & b2 \\ A31 & A32 & b3 \\ r & A42 & b4 \\ 0 & 0 & 0 \end{bmatrix}$$

The next step is to give x the value of A31 and n the value of r and form a new M matrix. Note that the old value of r is now called n. Now multiply the third and fourth rows by this matrix and the new matrix will be

$$\bar{A} = \begin{bmatrix} A11 & A12 & b1 \\ A21 & A22 & b2 \\ r & A32 & b3 \\ 0 & A42 & b4 \\ 0 & 0 & 0 \end{bmatrix}$$

This procedure is continued up to the diagonal element which is A11, then it is done in each of the remaining columns. After this is complete, the final matrix will look like

$$\bar{A} = \begin{bmatrix} A11 & A12 & b1 \\ 0 & A22 & b2 \\ 0 & 0 & b3 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

Keep in mind that these nonzero values are not the same as the values in the original matrix. Now the matrix is in the desired upper triangular form. In matrix form the equation looks like

$$\begin{bmatrix} A11 & A12 \\ 0 & A22 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} w1 \\ w2 \end{bmatrix} = \begin{bmatrix} b1 \\ b2 \\ b3 \end{bmatrix}$$

The values of the weights can be solved using the equations

$$A11*w1 + A12*w2 = b1$$

$$A22*w2 = b2$$

Using back substitution

$$w2 = b2/A22$$

$$w1 = (b1 - A12*w2)/A11$$

In summary Givin's method forms the matrix $\bar{A}$ = [A b], applies the algorithm to form $Q^H\bar{A}$ = [U Q^Hb], and then solves Uw = Q^Hb for w using back substitution.

III Processor Design and Emulation

3.1 EMUL

EMUL is a software tool which can be used to emulate a parallel processor design. The process starts by designing a processor architecture optimized for a specific algorithm. Basic building blocks such as delays, multipliers, adders etc... are connected together to form the processor. To design

an optimum processor for a specific algorithm the inherent parallelism of the algorithm must be identified and exploited. Parallelism is characterized by simple calculations which are similar and can be computed independently of other calculations. These simple calculations can be implemented using a few sub-processors sometimes referred to as cells. EMUL can be used to design and link cells together to build complete processors.

The simple algorithm shown in Equation 5 will be used to describe the process of designing, emulating and testing using EMUL.

$$(a^2+b^2)/(c^2+d^2)^{-1/2} \qquad (5)$$

Inspecting this algorithm for parallelism indicates that a, b, c, and d should be squared then the results used to form the numerator and denominator sums. This suggests two identical sub-processors/cells to compute the numerator and denominator sums. One possible design for the subject processor is shown in Figure 2. In Figure 2 "D1" means a delay of one, "Mult" means multiply, "Sum" means summation and "Inverse Square Root" means one over the square root of the input. The nodes and processor elements should be numbered as shown in Figure 2. The level of design in Figure 2 is required before using EMUL to emulate a processor. With Figure 2 in hand the example processor structure can be interactively input to EMUL. The

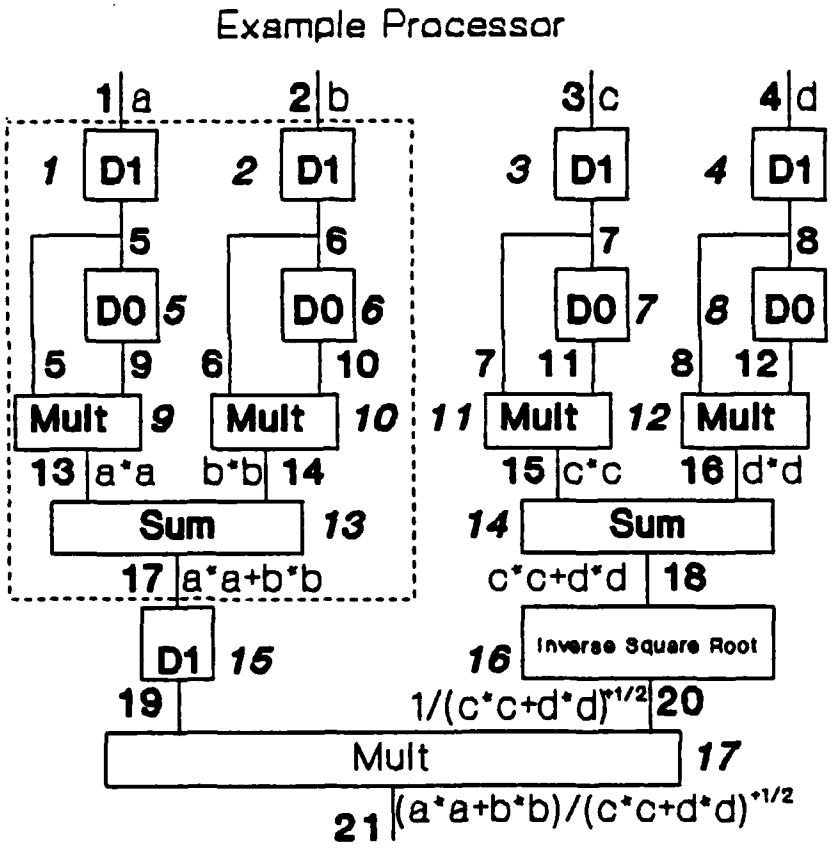

Figure 2

processor shown in Figure 2 can be simplified by combining the elements within the dotted line to form a cell. This cell is shown in Figure 3. At this point we are ready to use EMUL to emulate the cell and test its operation. A computer print out of an interactive session with EMUL to emulate and test the subject cell is contained in Appendix A. Using EMUL interactively a system specification file will be created. For the cell shown in Figure 3 the file is called EXPCEL.SSF and is contained in Appendix A. This file for each element in the

Example Cell

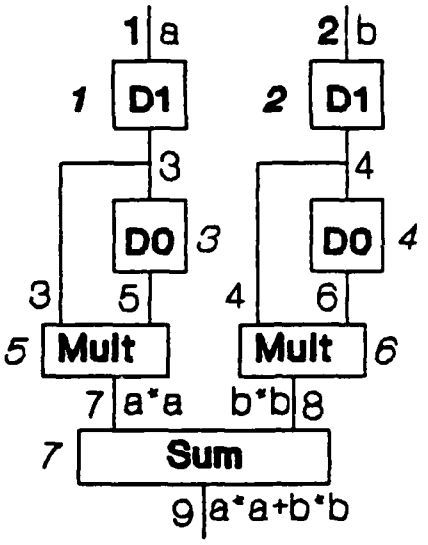

Figure 3

cell contains the input and output node numbers, fixed or floating point specification, type of element, number of bits of precision and the delay through the element. Once a .SSF file is complete, a test run specification file must be developed. For the subject cell this file is called EXPCEL.TSF and is also contained in Appendix A. The .TSF file contains the number of input data snapshots, number of elements in the processor/cell, the number of cells within the processor and the input node, input data value and the input element number for each input to the processor/cell. Once these two files are complete the simulation/emulation can be run. The emulation produces an output file called EXPCEL.OUT which is

contained in Appendix A. The .OUT file contains the inputs and outputs of all elements processing data for each clock cycle and for each data snapshot.

In Figure 4 the complete example system is shown. This system incorporates the cell previously developed. The interactive session listing, .SSF, .TSF, and .OUT files, are contained in Appendix B. One important item to note is that cells can contain no more than 99 elements. Appendix B can be studied for correct operation of EMUL.

All algorithms exhibit some degree of parallelism and

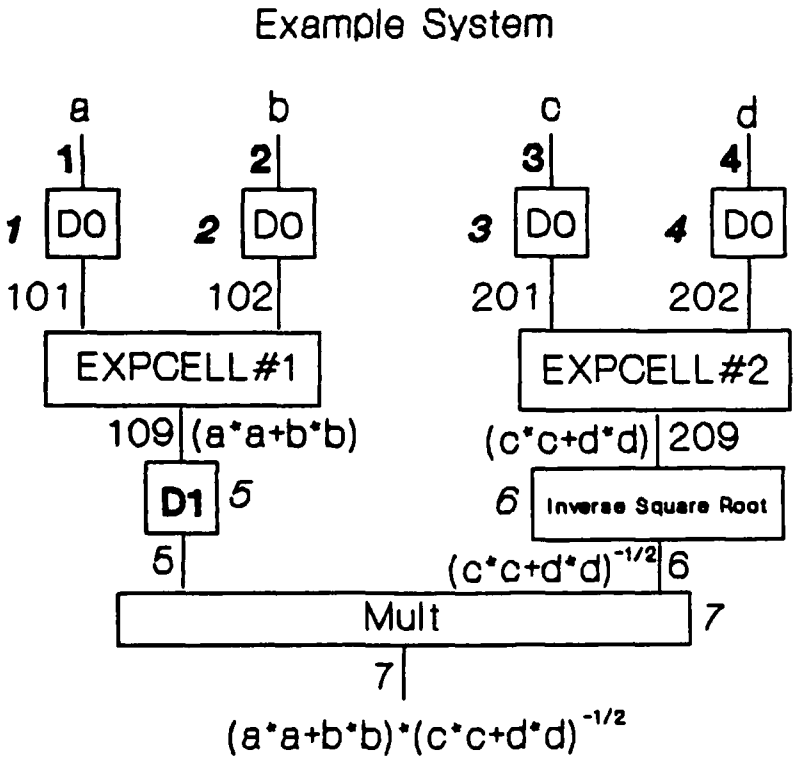

Figure 4

nonparallelism. When parallelism exists it can be exploited as shown in the example above. When nonparallism exists, such as a processor performing vector dot products, a sum of products is necessary. This requires that the output of a summing element be fed back to its input. Such a feed back element configuration is shown in Figure 5. Note the dotted line connected to input node number two. This node can be initialized on the first snapshot to any convenient constant. The interactive emulation file for this example is contained in Appendix C. Note that node two is initialized to zero and the element adds all the numbers presented at node one for subsequent clock cycles.

Element Feedback Example

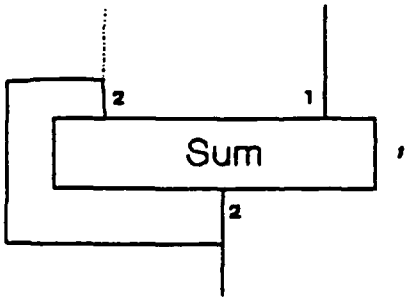

Figure 5

3.2 Emulation of the Sample Matrix Inversion Processor

The SMI algorithm consists basically of two major steps. The first step is to form a correlation matrix from the received antenna array data and the second step is to invert that matrix to obtain the weight vector. The SMI processor consists of two subprocessors which implement these two steps. In Figure 6 one subprocessor is referred to as the "COMPLEX

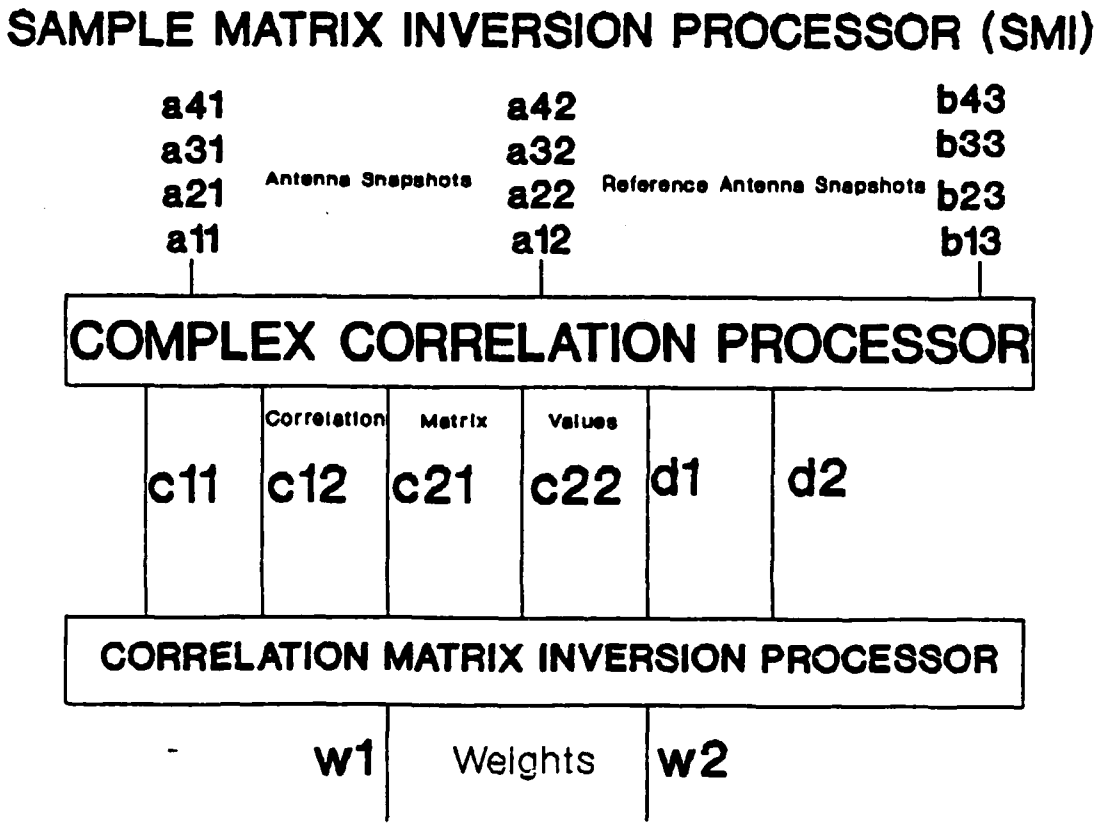

Figure 6

CORRELATION PROCESSOR" and the second subprocessor is referred to as the "CORRELATION MATRIX INVERSION PROCESSOR". As shown in Figure 6 these two processors together form the SMI processor.

The "COMPLEX CORRELATION PROCESSOR" is shown in Figure 7. Only two cells were needed to implement this processor. The Complex Vector Magnitude Cell (CVMcell) is shown in Figure 8. This cell performs a complex vector dot product of a vector

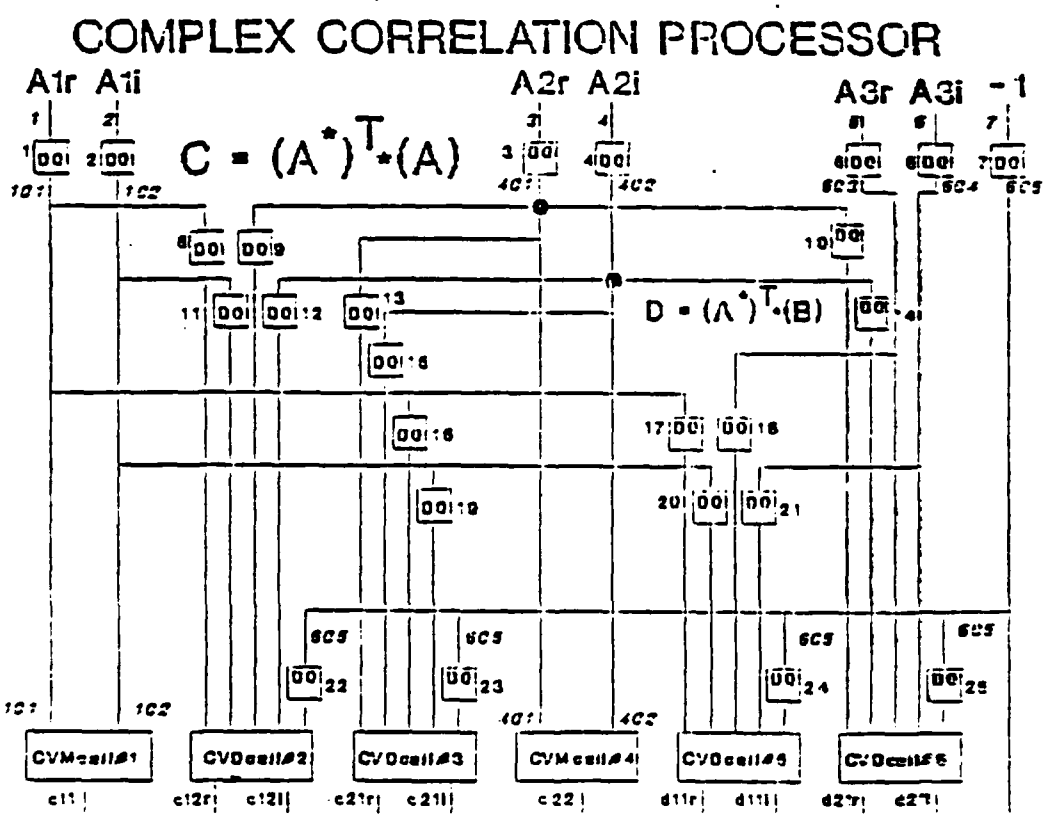

Figure 7

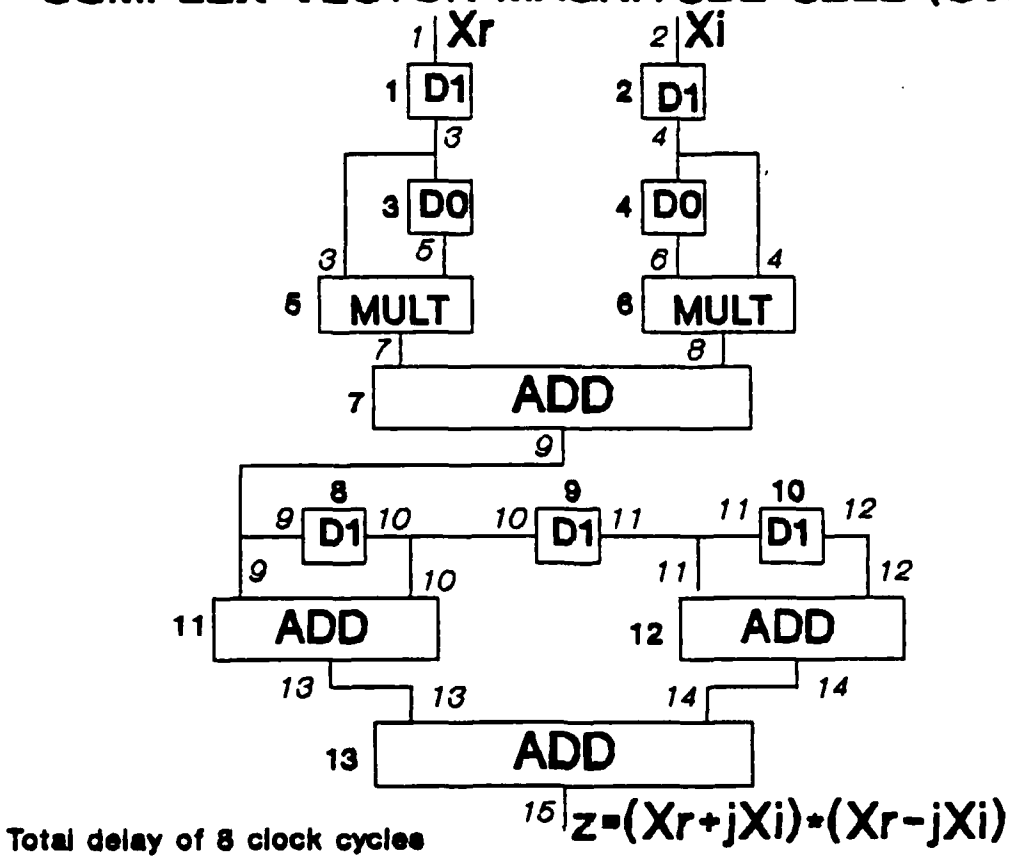

Figure 8

with itself. The Complex Vector Dot Product Cell (CVDcell) is shown in Figure 9. This cell performs a complex vector dot product for any two complex vector inputs. Note that a -1 input must be applied to Element 13 to form the conjugate. Both of these cells operate on vectors of size four and output valid results every eight clock cycles.

The "CORRELATION MATRIX INVERSION PROCESSOR" is shown in Figure 10. Two cells were used to implement this subprocessor.

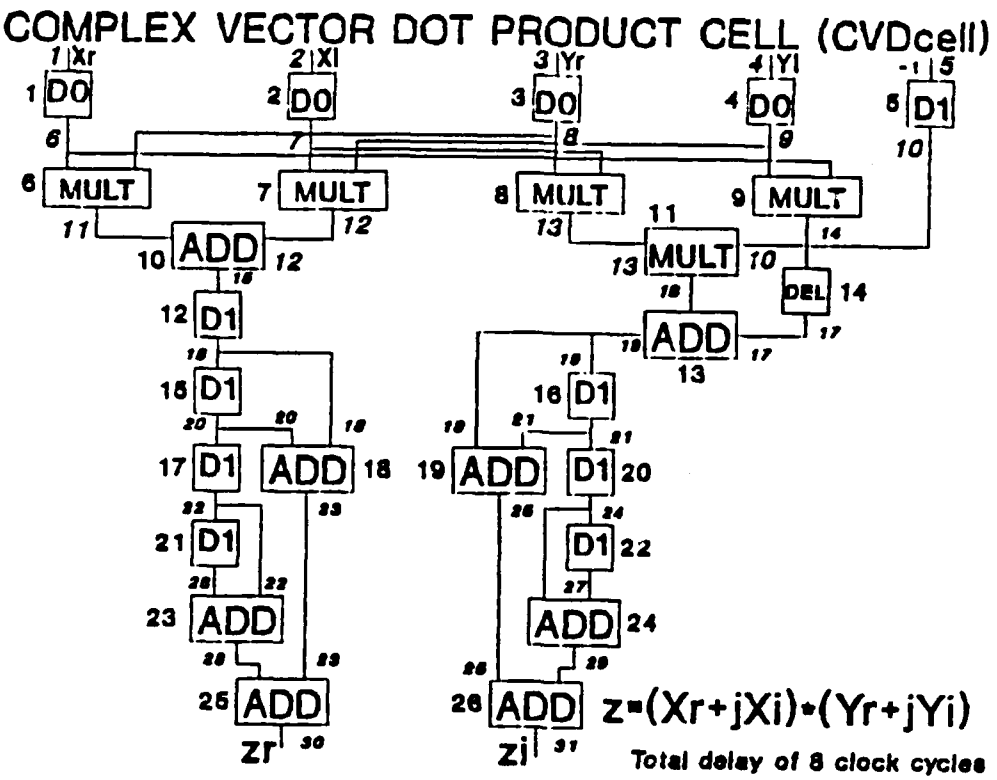

Figure 9

The Inverse determinate cell (IDTcell) is shown in Figure 11. This cell computes the determinate of the correlation matrix and divides this quantity into one using a one over the square root element. Note that -1 is used to perform subtraction. The Weight Cell (WTcell) is shown in Figure 12. This cell also uses multiplication by -1 to do later subtractions. The associated emulation files are in Appendix D.

3.3 Emulation of the Unitary Transformations Processor

When designing the hardware needed for implementing

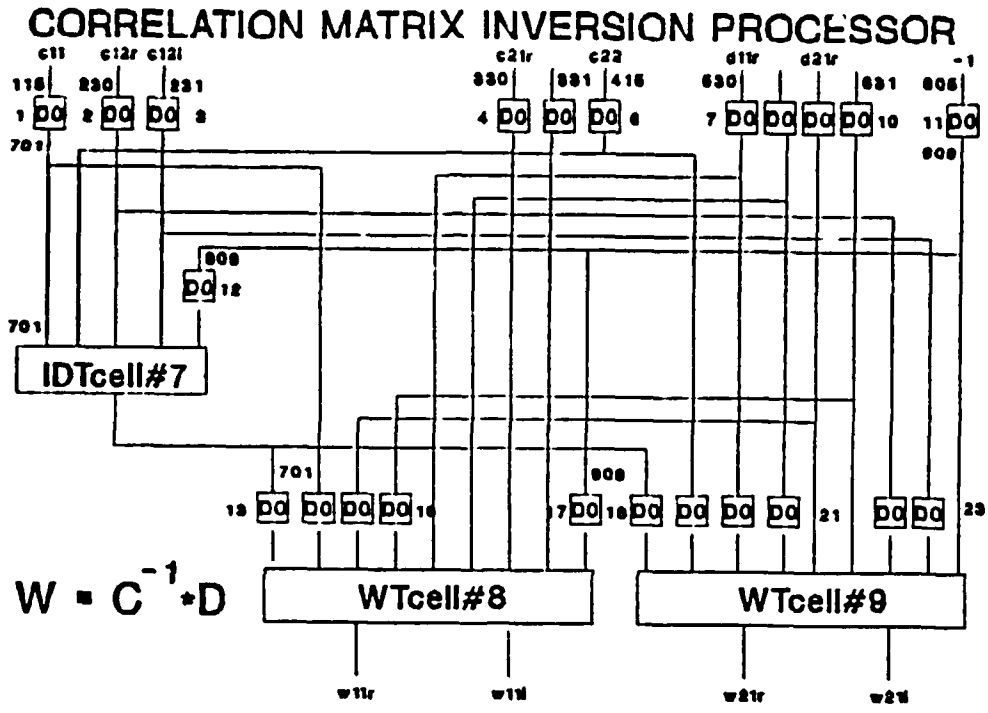

Figure 10

Givin's method, two types of arrays are needed: the QU array and the backsolve array. The QU array forms the [U $Q^H b$] matrix and is composed of two types of cells. The boundary cell calculates the values of c and s for the M matrix, and the internal cell applies the M matrix to the $\bar{A}$ matrix. Since the three element adaptive array that was used in the previous example will also be the one used on the systolic array processor emulator, the backsolve array will be very simple and can be designed as a single cell. Therefore, three types of cells are required.

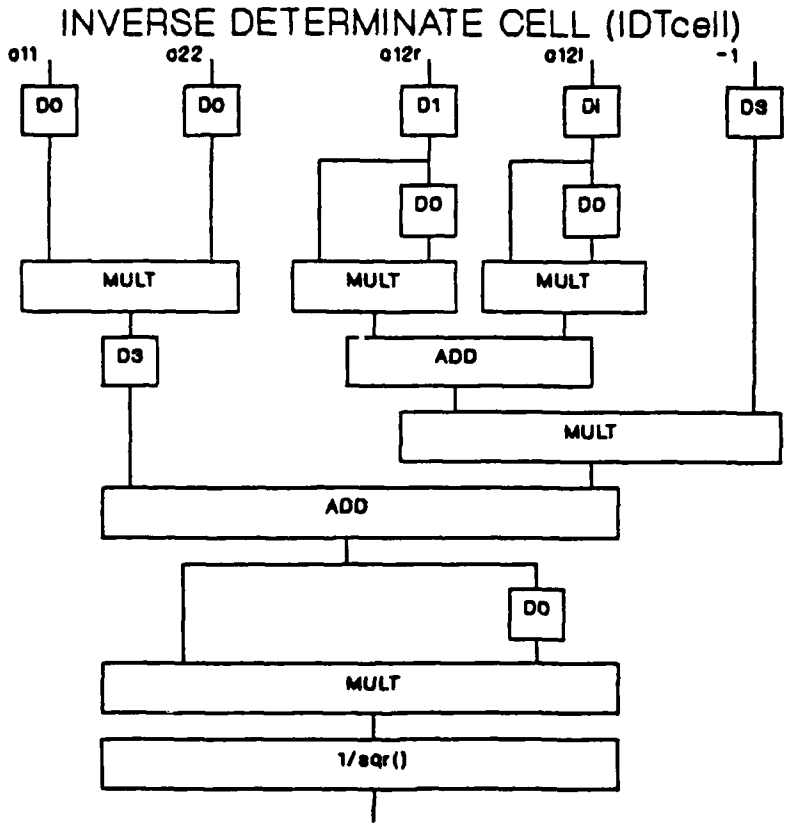

Figure 11

The "BOUNDARY CELL", shown in Figure 13, creates the Givin's rotation matrices. The outputs of this cell are the values of c and s. The elements of a column of the $\bar{A}$ matrix are input to the cell starting with the bottom row at the inputs Xr and Xi which are the real and imaginary components. There will be one of these cells for every column of the matrix (for every antenna element). On the right hand side of the cell the components of the input (r) are squared and summed producing the square of the magnitude (r^2). This value is summed with n^2 (which is the previous value of r^2, and in the first case is zero), and the inverse of the square root of this

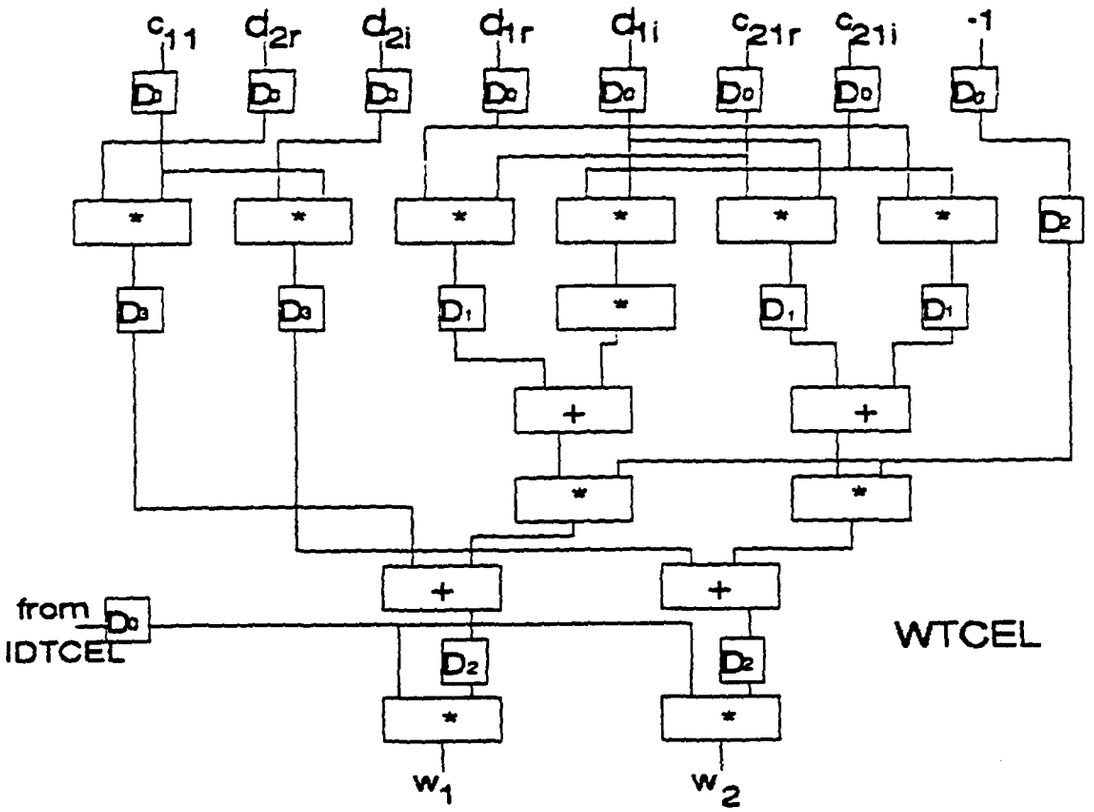

Figure 12

value is taken to give the new value of 1/r. Multipliers 17, 18, and 19 produce the value of c and multiplier 21 produces s. Note that s is output one cycle later than c. Multiplier 20 recovers the value of n by recovering the previous value of r by multiplying together the previous values of r^2 and 1/r.

The "INTERNAL CELL", shown in Figure 14, applies Givin's rotations to a single column of $\bar{A}$. The bottom most element of the column falls through to become the first value of y. This is done by having the first values of c and s to be equal

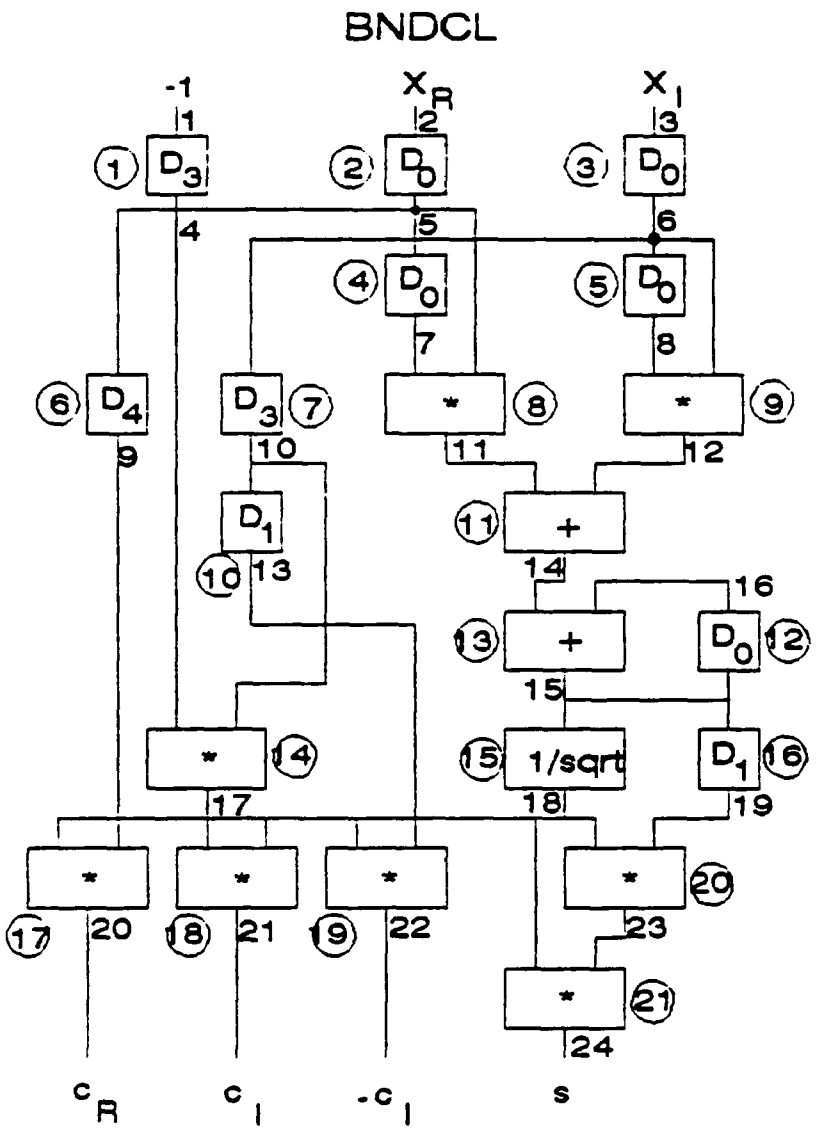

Figure 13

to 1 and 0 respectively. The delays of multipliers 8 through 13, adders 20, 21, 28 and 29, and delays 22 and 23 are set to be 0 so that the value of y will be ready on the next clock cycle. This seemed to be the only sensible way to emulate the processor, because there is no way to have a delay equal to a

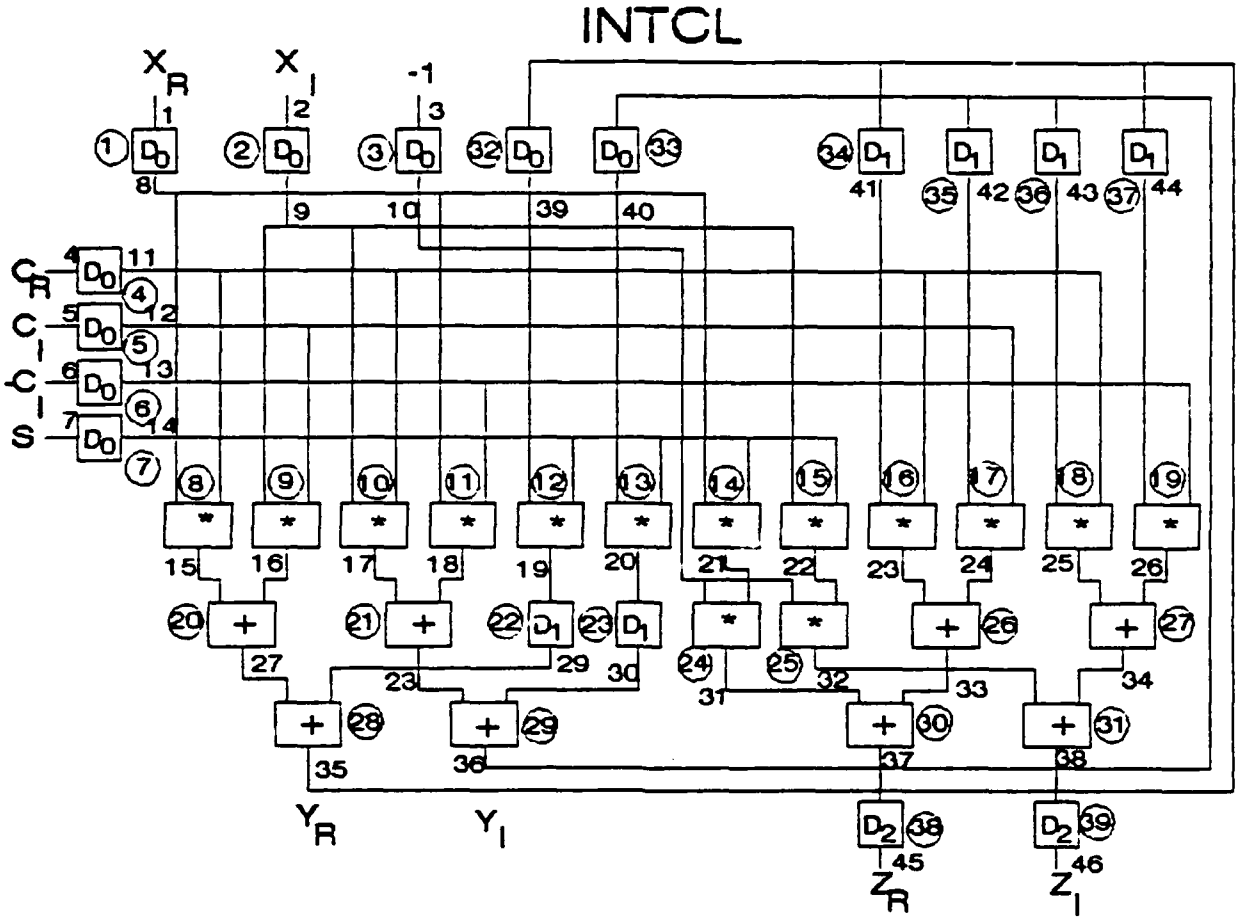

Figure 14

fraction of the time of a snapshot. After the rotations are applied to x and y, these values are called y and z. The value of z is output, and y is fed back to be used in the next rotation. This is done up to the diagonal element in the $\bar{A}$ matrix. The equations for calculating these values are

$$Yr = CrXr - CiXi + SYr$$
$$Yi = CrXi + CiXr + SYi$$
$$Zr = CrYr + CiYi - SXr$$
$$Zi = CrYi - CiYr - SXi$$

The "BACKSUBSTITUTION CELL" is shown in Figure 15. This

BACSUB

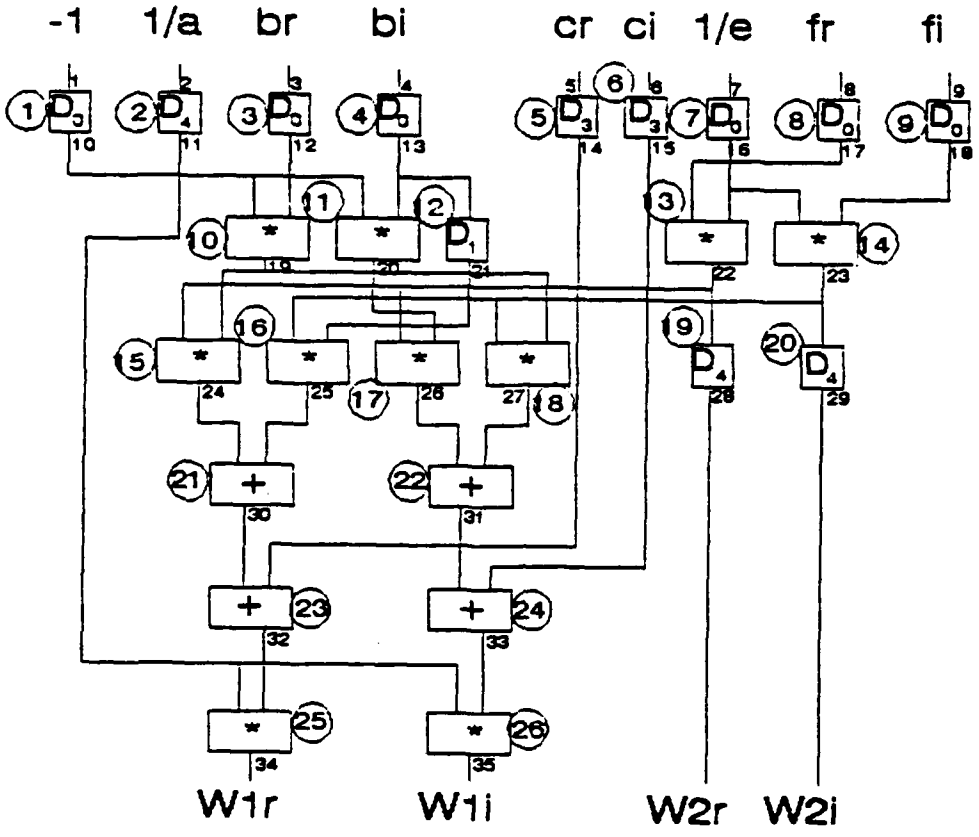

Figure 15

cell is straight forward and computes the weights through the equations

$$w2 = b2/A22 \text{ and}$$

$$w1 = (b1 - A12*w2)/A11$$

In the figure the equations are

$$w2 = f/e \text{ and}$$

$$w1 = (c - b*w2)/a$$

The full form of the "GIVIN'S METHOD WEIGHT COMPUTER" is in the same formation as the final A matrix, and is shown in Figure 16. The three columns are input into the top three cells. Final values of 1/A11, A12, A13, 1/A22, and A23 are produced from boundary cell 1, internal cell 2 and 3, boundary

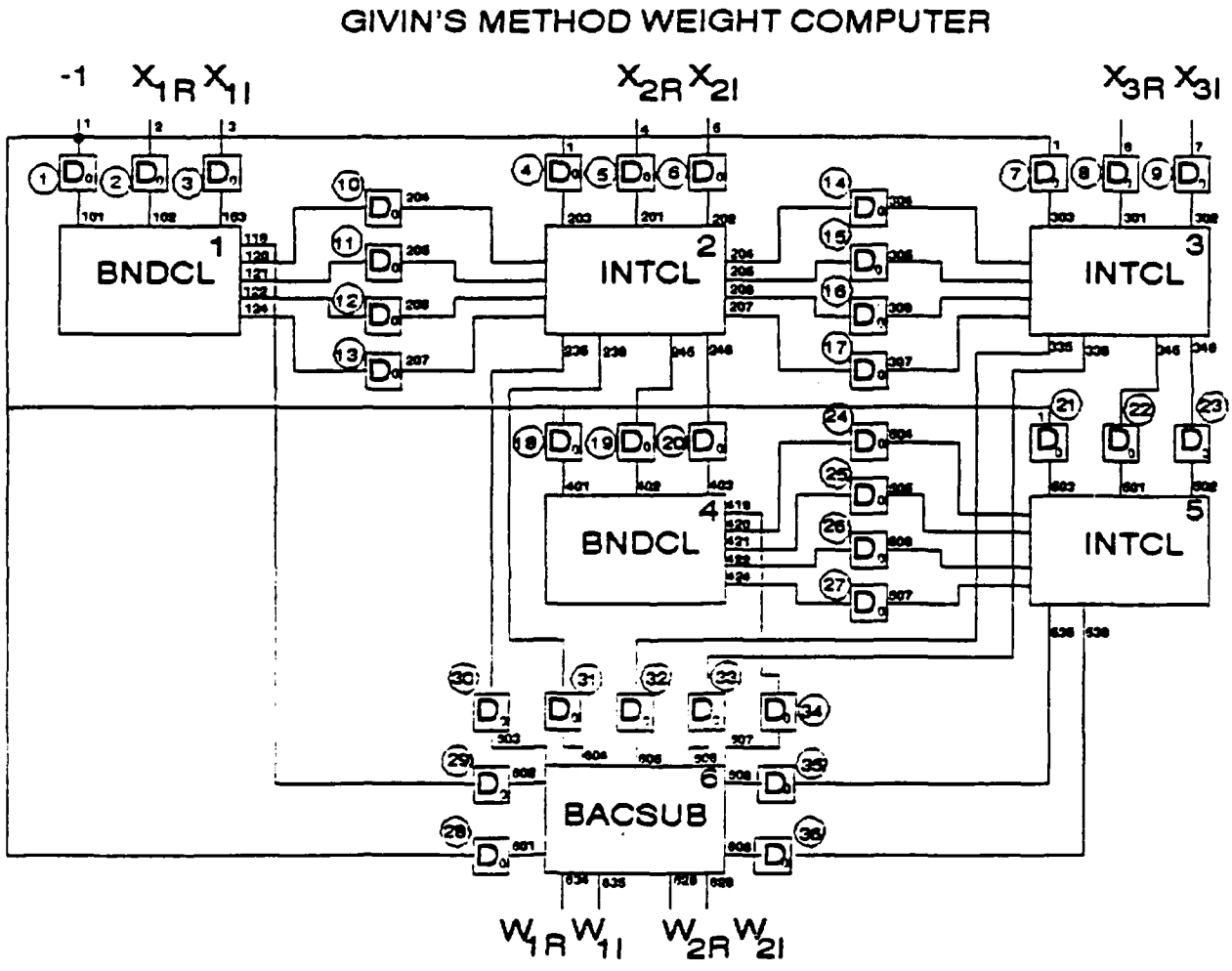

Figure 16

cell 4, and internal cell 5 respectively. These values are then fed into the back substitution cell. The column 2 inputs must be delayed until the values of c and s are ready from the column 1 boundary cell. The column three inputs must also be delayed because internal cell 5 must wait for the boundary cell in column two. These delays are added to the cells internally as well as delays used so that the outputs of one cell will arrive at the inputs of other cells at the right time. These delays are the factors that limit the speed of the processor. The emulation files for these cells are in Appendix E.

IV Processor Test and Evaluation

4.1 GADAR

GADAR is a software tool which allows a user to emulate a design of a single or multiple antenna receiver system. A simplified single antenna element receiver system is shown in Figure 17. The system is emulated by connecting together elements, numbering elements, defining and numbering nodes where elements are connected and choosing the performance parameters of each element. Receive antennas and emitting sources can be positioned in a three dimensional coordinate system to allow emulation of various communications system scenarios. The output of the system shown in Figure 17 is in-phase and quadrature digital base band data from the analog

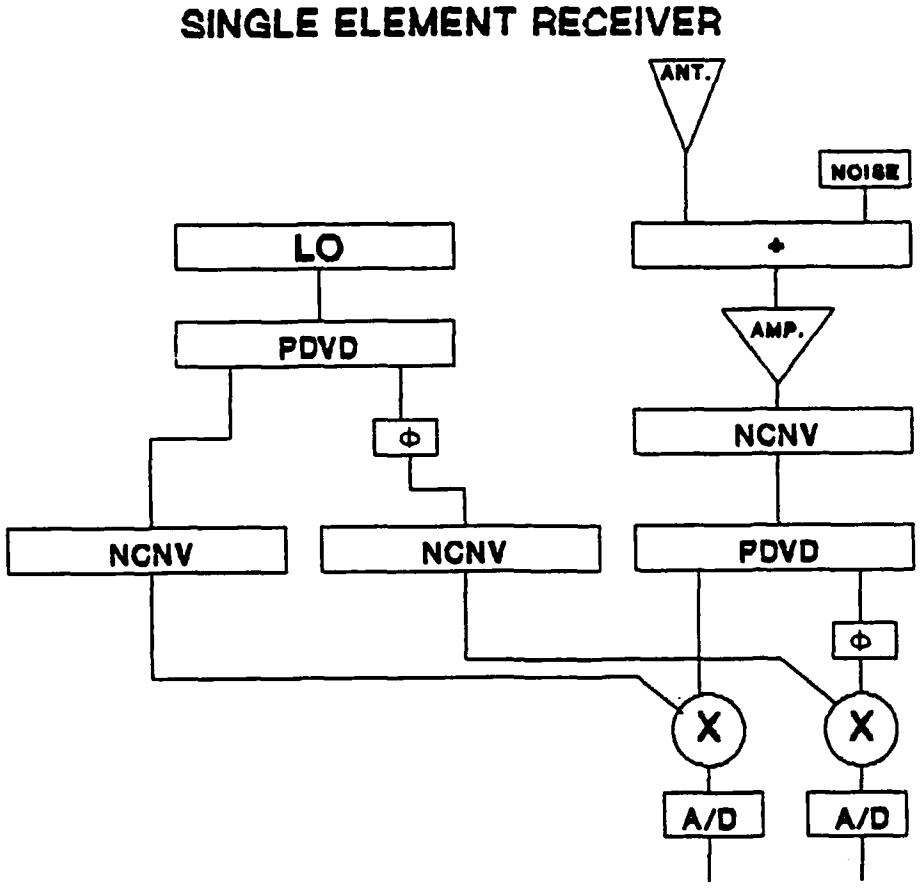

Figure 17

to digital converters 14 and 15. An interactive emulation file for this single element receiver system is contained in Appendix F.

4.2 Testing of the SMI Processor

Using GADAR a three element receiver system was designed and emulated. The three element receiver system is shown in Figure 18. The output of the three element receiver is

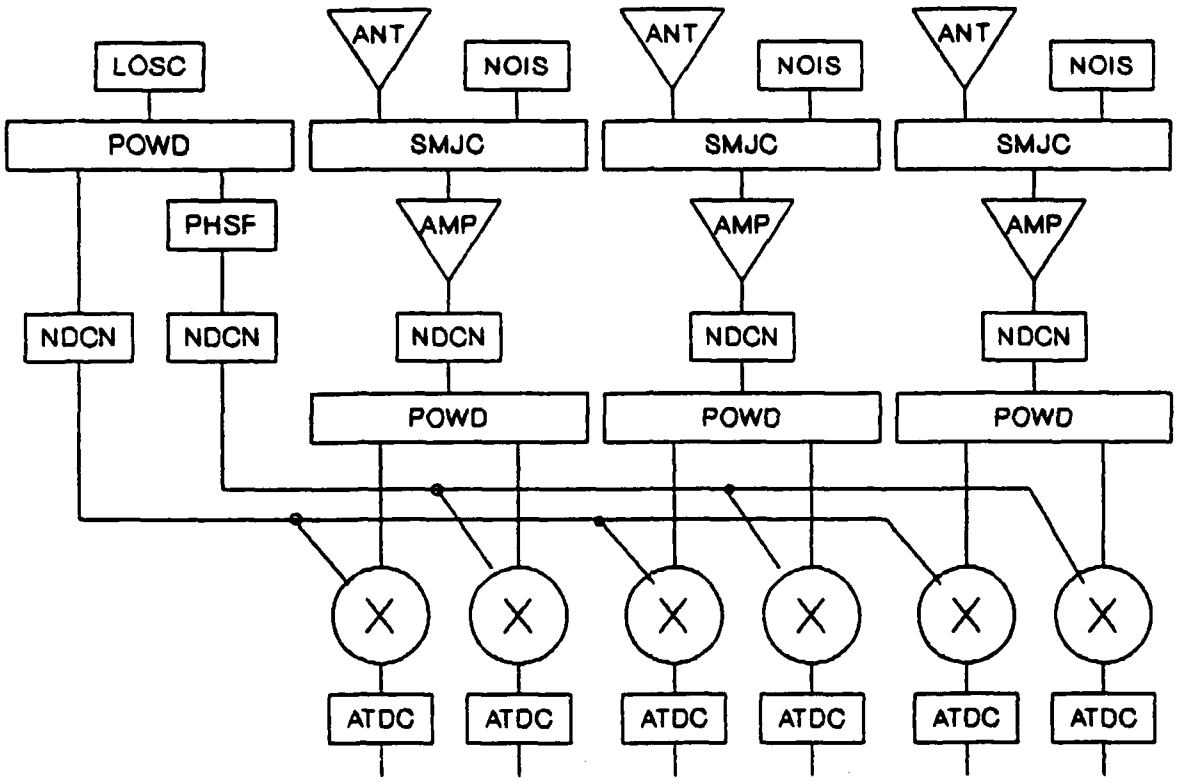

Figure 18

in-phase and quadrature baseband digital samples from the three antenna elements of the emulated array receiver system. An interactive file showing the emulation process of the three element system and the output data file is included in Appendix G. The data represents a single sinusoidal interference source broad side to the three element array. The output file of GADAR is used as an input file to EMUL for the emulation of the SMI processor described in Section 3.2. In Figure 18 the symbols are Local Oscillator (LOSC), Power Divider (POWD), Phase

Shifter (PHSF), Node Conversion (NDCN), Antenna (ANT), NoiseSource (NOIS), Summing Junction (SMJC), Amplifier (AMP), Analog To Digital Converter (ATDC) and a circle with an x inside is a Mixer/Multiplier. Using the data from the three element receive array the SMI processor computed two weights for application to the two adapted elements. The complex weights computed by the SMI processor are (0.367,0.338), (0.367,0.337). Using the equations described in Section 2.2 the weights were computed to be (0.385,0.354), (0.385,0.354). Four samples were averaged to obtain the SMI processor result. Using "An Adaptive Satellite Communication Analysis Computer Program (SATCOM)" [4] an adaptive antenna patterns plot was generated. The adaptive antenna pattern is shown in Figure 19 where the dotted line is the broadside steered conventional three element pattern and the solid line is the adaptive gain pattern with the SMI computed weights applied to the GADAR generated data. The pattern shows about a 18db null in the direction of the interference source. Other patterns were run with similar results verifying the proper operation of the SMI processor. Using the element feedback technique described in Section 3.1 the SMI processor could be designed to average large numbers of samples to provide improved performance.

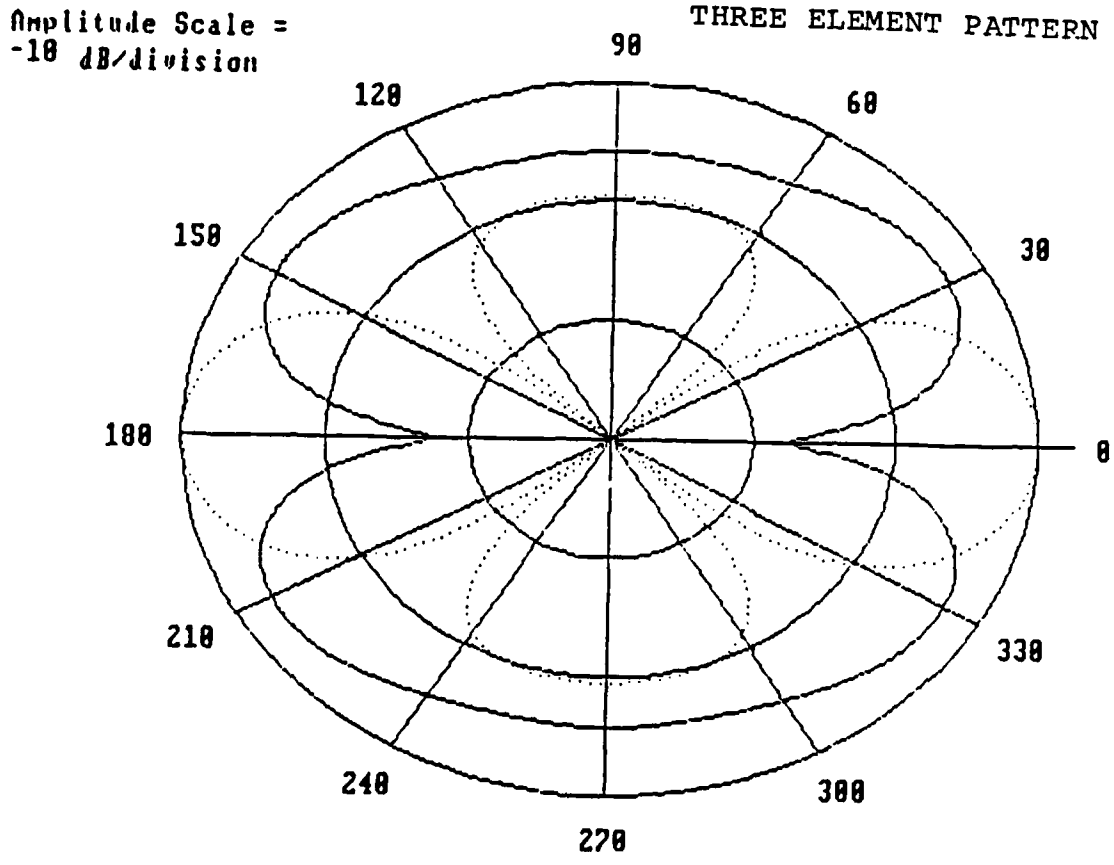

Figure 19

4.3 Testing of the Unitary Transformations Processor

The data generated using GADAR was also used for testing the Givin's method weight computer. The results were identical to the results using the equations. These were (.385, .354) and (.385, .354). These results were output on the 24th cycle of snapshot 1 and the 22nd cycle of snapshot 3. They are shown in the output file in Appendix E.

V Conclusions

This report covers the process of designing and emulating an adaptive antenna processor, designing and emulating an adaptive antenna receive system and using the output of the antenna receive system to test the emulated adaptive antenna processor. The work done has shown that EMUL and GADAR can be effectively used to design and emulate adaptive signal processing systems. The design, emulation and testing of a system in this fashion can provide a high degree of confidence that a hardware implementation will be functionally correct. Intermediate numerical results obtained from the emulation can provide a means of checking hardware design operation. The use of element feedback techniques can increase processor performance and reduce processor latency. The main limitation of the emulation is that the size of the processor design is limited by 99 available cells.

VI Recommendations

This work shows that many adaptive signal processing systems, specifically adaptive antenna processing systems, could benefit from the application of highly pipelined parallel digital systolic processors. Highly specialized parallel digital processors can greatly enhance the speed and dynamic range with which specific signal processing algorithms can be

implemented. This approach can provide the power necessary to solve computationally intensive signal processing problems in real time. GADAR and EMUL should be enhanced to handle larger problems. The addition of nonlinear elements to EMUL would also allow the emulation of certain types of neural net signal processing systems suitable for real time adaptive communication signal processing needs.

References

[1] Hazeltine Corporation, "Systolic Array Processor Brassboard", RADC-TR-89-62, June 1989. (B136 000L)

[2] Widrow, "Adaptive Signal Processing", Prentice-Hall, 1985.

[3] ESL-A Subsidiary of TRW, "High Speed Adaptive Signal Processing Final Report", RADC-TR-85-53, March 1985 (B095 367)

[4] Syracuse Research Corporation, "An Adaptive Satellite Communications Analysis Computer Program User's Manual (SATCOM)", SRC TR 89-1528, November 1989.

Appendix A

Interactive Example Cell Emulation File

```
        Welcome to VAX/VMS V5.1

Username: SMITHR
Password:
        Welcome to VAX/VMS version V5.1 on node MISVX1
    Last interactive login on Friday, 15-DEC-1989 10:05Z>
®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®
 Lookup the phone number and office symbol of RADC personel, use the
 FIND command.
-----------------------------------------------------------------------------
 Send your MISVAX files to a LONEX printer, use the LP command.
-----------------------------------------------------------------------------
 To get information on special utilities installed on the 8650 cluster,
 type 'help @RADC' at the $ prompt.
/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/®/>
$ DIR

Directory DC$DISK2:[SMITHR]

BOTH.DIR;1          EMUL.DIR;1          GADAR.DIR;1         INFO.DIR;1
LOGIN.COM;4         LOGIN.COM;3         LOGIN.COM;2         LOGIN.JOU;1
SYSTEM.DIR;1

Total of 9 files.
$ SET DEF [SMITHR.EMUL]
$ DIR

Directory DC$DISK2:[SMITHR.EMUL]

ALGOR1.TSF;1        BACSUB.SSF;1        BACSUB.TSF;1        BNDCEL.SSF;1
BNDCEL.TSF;1        CACEL.SSF;1         CBACSB.SSF;1        CBNDC2.SSF;1
CBNDCL.SSF;1        CBNDCL.TSF;1        CCMCEL.SSF;1        CCOREL.SSF;1
CCOREL.TSF;1        CINTC2.SSF;1        CINTCL.SSF;1        CMCEL.SSF;1
CMULCL.SSF;1        CMULCL.TSF;1        CMXSOL.SSF;1        CMXSOL.TSF;1
COM.DIR;1           CORREL.SSF;1        CSMCEL.SSF;1        CSMI.SSF;1
CSMI.TSF;1          CVDCEL.SSF;1        CVMCEL.SSF;1        EMUL.EXE;1
GIV2.SSF;1          GIV2.TSF;1          GIV3.SSF;1          GIV3.TSF;1
GIV4.SSF;1          IDTCEL.SSF;1        IDTCEL.TSF;1        INTCEL.SSF;1
INTCEL.TSF;1        MATSOL.SSF;1        SMI.SSF;1           SOURCE.DIR;1
TEST.DIR;1          WTCEL.SSF;1         WTCEL.TSF;1

Total of 43 files.
$ RUN EMUL

     THIS IS THE GENERAL PURPOSE ADAPTIVE ARRAY PROGRAM EMUL.  EMUL IS
     CAPABLE OF SIMULATING A COMMUNICATION SYSTEM HAVING RECEIVING
     ELEMENTS IN SPACE EXCITED BY A SIMULATED SCENARIO.  THE SYSTEM IS
     SPECIFIED BY THE INTERCONNECTION OF STANDARD COMPONENT BUILDING
     BLOCKS INTERCONNECTED AT NODES.

     SYSTEM AND TEST RUN PARAMETERS ARE SPECIFIED BY THE USER IN AN
     INTERACTIVE DIALOG AND WRITTEN TO FILES.  THESE FILES ARE THEN USED
     TO SPECIFY SYSTEM CONFIGURATION AND TESTING MODE AT RUN TIME.

     THERE ARE THREE TYPES OF ANSWERS TO QUESTIONS USED IN THE
     INTERACTIVE PROGRAM CONSISTING OF YES AND NO, MENU SELECT, AND
     PARAMETER SPECIFICATION.  ALL USER COMMANDS MUST BE TERMINATED BY A
     CARRIAGE RETURN ('<CR>').
```

```
    THERE ARE SEVERAL COMMANDS THAT WILL BE VALID AT ANY  TIME  THAT  A
    RESPONSE  FROM  YOU, THE USER, IS REQUIRED.  THESE COMMANDS CONSIST
    OF THE FOLLOWING:
         HELP-ADDITIONAL DETAILS ARE REQUESTED FOR QUESTION.
         EXIT-EXIT AFTER CLOSING FILES PRESENTLY BEING WRITTEN.
         BREAK-CLOSE FILES AND RETURN TO OPERATION SELECTION.

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         D   EXIT FROM EMUL
B

    WHAT IS THE NAME OF THE CONFIGURATIN SPECIFICATION FILE
    TO BE OPENED FOR WRITING?
EXPCEL.SSF

    Select a component type for component      1.
         A   Cell (this is a heading for chips to then be specified)
         B   Add Chip
         C   Multiply Chip
         D   Delay Chip
         E   Look Up Chip
         F   quit (terminate structure entry)
D

    Component number      1 is of type:   DELY.  What is the one  input
    node number for this component?
1

    What is the output node number for this component?
3

    What numerical format is desired for this format?
         A   floating point
         B   fixed point
A

    Should the component be 16 bit or 32 bit?
         A   16
         B   32
B

    How many clock cycles is this chip?
1

    The following parameters have been specified for component      1 of
    type  DELY.  Do you wish to change anything?  (yes or no)
         First input node:       1
         Output node:       3
         Numerical format:    FLOT
         16 bit or 32 bit size:      32
         Clock cycle(s):       1
NO

    Select a component type for component      2.
         A   Cell (this is a heading for chips to then be specified)
         B   Add Chip
```

```
        C   Multiply Chip
        D   Delay Chip
        E   Look Up Chip
        F   quit (terminate structure entry)
D

    Component number     2 is of type:   DELY.  What is the one  input
    node number for this component?
2

    What is the output node number for this component?
4

    What numerical format is desired for this format?
        A   floating point
        B   fixed point
A

    Should the component be 16 bit or 32 bit?
        A   16
        B   32
B

    How many clock cycles is this chip?
1

    The following parameters have been specified for component     2 of
    type  DELY.  Do you wish to change anything?  (yes or no)
        First input node:       2
        Output node:      4
        Numerical format:   FLOT
        16 bit or 32 bit size:      32
        Clock cycle(s):       1
NO

    Select a component type for component     3.
        A   Cell (this is a heading for chips to then be specified)
        B   Add Chip
        C   Multiply Chip
        D   Delay Chip
        E   Look Up Chip
        F   quit (terminate structure entry)
D

    Component number     3 is of type:   DELY.  What is the one  input
    node number for this component?
3

    What is the output node number for this component?
5

    What numerical format is desired for this format?
        A   floating point
        B   fixed point
A

    Should the component be 16 bit or 32 bit?
        A   16
        B   32
B
```

```
    How many clock cycles is this chip?
0

    The following parameters have been specified for component     3 of
    type  DELY.  Do you wish to change anything?  (yes or no)
         First input node:      3
         Output node:      5
         Numerical format:   FLOT
         16 bit or 32 bit size:     32
         Clock cycle(s):      0
NO

    Select a component type for component     4.
         A   Cell (this is a heading for chips to then be specified)
         B   Add Chip
         C   Multiply Chip
         D   Delay Chip
         E   Look Up Chip
         F   quit (terminate structure entry)
D

    Component number     4 is of type:   DELY.  What is the one  input
    node number for this component?
4

    What is the output node number for this component?
6

    What numerical format is desired for this format?
         A   floating point
         B   fixed point
A

    Should the component be 16 bit or 32 bit?
         A   16
         B   32
B

    How many clock cycles is this chip?
0

    The following parameters have been specified for component     4 of
    type  DELY.  Do you wish to change anything?  (yes or no)
         First input node:      4
         Output node:      6
         Numerical format:   FLOT
         16 bit or 32 bit size:     32
         Clock cycle(s):      0
NO

    Select a component type for component     5.
         A   Cell (this is a heading for chips to then be specified)
         B   Add Chip
         C   Multiply Chip
         D   Delay Chip
         E   Look Up Chip
         F   quit (terminate structure entry)
C
```

```
    Component number     5 is of type:   MULT.  What is input node
    number    1for this component?
3

    Component number     5 is of type:   MULT.  What is input node
    number    2for this component?
5

    What is the output node number for this component?
7

    What numerical format is desired for this format?
         A   floating point
         B   fixed point
A

    Should the component be 16 bit or 32 bit?
         A   16
         B   32
B

    How many clock cycles is this chip?
1

    The following parameters have been specified for component     5 of
    type  MULT.  Do you wish to change anything?  (yes or no)
         First input node:      3
         Second input node:      5
         Output node:      7
         Numerical format:   FLOT
         16 bit or 32 bit size:     32
         Clock Cycle(s):      1
NO

    Select a component type for component     6.
         A   Cell (this is a heading for chips to then be specified)
         B   Add Chip
         C   Multiply Chip
         D   Delay Chip
         E   Look Up Chip
         F   quit (terminate structure entry)
C

    Component number     6 is of type:   MULT.  What is input node
    number    1for this component?
4

    Component number     6 is of type:   MULT.  What is input node
    number    2for this component?
6

    What is the output node number for this component?
8

    What numerical format is desired for this format?
         A   floating point
         B   fixed point
A

    Should the component be 16 bit or 32 bit?
```

```
        A   16
        B   32
B

    How many clock cycles is this chip?
1

    The following parameters have been specified for component     6 of
    type  MULT.  Do you wish to change anything?  (yes or no)
         First input node:      4
         Second input node:      6
         Output node:      8
         Numerical format:   FLOT
         16 bit or 32 bit size:     32
         Clock Cycle(s):      1
NO

    Select a component type for component     7.
         A   Cell (this is a heading for chips to then be specified)
         B   Add Chip
         C   Multiply Chip
         D   Delay Chip
         E   Look Up Chip
         F   quit (terminate structure entry)
B

    Component number     7 is of type:   ADDR.  What is input node
    number    1for this component?
7

    Component number     7 is of type:   ADDR.  What is input node
    number    2for this component?
8

    What is the output node number for this component?
9

    What numerical format is desired for this format?
         A   floating point
         B   fixed point
A

    Should the component be 16 bit or 32 bit?
         A   16
         B   32
B

    How many clock cycles is this chip?
1

    The following parameters have been specified for component     7 of
    type  ADDR.  Do you wish to change anything?  (yes or no)
         First input node:      7
         Second input node:      8
         Output node:      9
         Numerical format:   FLOT
         16 bit or 32 bit size:     32
         Clock Cycle(s):      1
NC
```

```
    Select a component type for component     8.
         A   Cell (this is a heading for chips to then be specified)
         B   Add Chip
         C   Multiply Chip
         D   Delay Chip
         E   Look Up Chip
         F   quit (terminate structure entry)
F

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         D   EXIT FROM EMUL
D
$ TYPE EXPCEL.SSF
ONFIGURATIN
    1    0    3    FLOT   DELY    32    1
    2    0    4    FLOT   DELY    32    1
    3    0    5    FLOT   DELY    32    0
    4    0    6    FLOT   DELY    32    0
    3    5    7    FLOT   MULT    32    1
    4    6    8    FLOT   MULT    32    1
    7    8    9    FLOT   ADDR    32    1
$ RUN EMUL

    THIS IS THE GENERAL PURPOSE ADAPTIVE ARRAY PROGRAM EMUL.  EMUL IS
    CAPABLE OF SIMULATING A COMMUNICATION SYSTEM HAVING RECEIVING
    ELEMENTS IN SPACE EXCITED BY A SIMULATED SCENARIO.  THE SYSTEM IS
    SPECIFIED BY THE INTERCONNECTION OF STANDARD COMPONENT BUILDING
    BLOCKS INTERCONNECTED AT NODES.

    SYSTEM AND TEST RUN PARAMETERS ARE SPECIFIED BY THE USER IN AN
    INTERACTIVE DIALOG AND WRITTEN TO FILES.  THESE FILES ARE THEN USED
    TO SPECIFY SYSTEM CONFIGURATION AND TESTING MODE AT RUN TIME.

    THERE ARE THREE TYPES OF ANSWERS TO QUESTIONS USED IN THE
    INTERACTIVE PROGRAM CONSISTING OF YES AND NO, MENU SELECT, AND
    PARAMETER SPECIFICATION.  ALL USER COMMANDS MUST BE TERMINATED BY A
    CARRIAGE RETURN ('<CR>').

    THERE ARE SEVERAL COMMANDS THAT WILL BE VALID AT ANY TIME THAT A
    RESPONSE FROM YOU, THE USER, IS REQUIRED.  THESE COMMANDS CONSIST
    OF THE FOLLOWING:
         HELP-ADDITIONAL DETAILS ARE REQUESTED FOR QUESTION.
         EXIT-EXIT AFTER CLOSING FILES PRESENTLY BEING WRITTEN.
         BREAK-CLOSE FILES AND RETURN TO OPERATION SELECTION.

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         D   EXIT FROM EMUL
C

    WHAT IS THE NAME OF THE EXPERIMENT   SPECIFICATION FILE
    TO BE OPENED FOR WRITING?
EXPCEL.TSF

    At this time EMUL requires a general knowledge of the system that
```

```
    will  now be tested.  How many input snapshots of the input data do
    you want to process?
1

    What  are  the  total  number  of  chips  in  the  system  you  are
    specifying, that are not located within a cell?
7

    What are the total number of cells in the array processor?
0

    The following parameters have been specified for this system.  Do you wish t
o change anything?(yes or no)
          Number of snapshots:      1
          Number of chips:      7
          Number of cells:      0
NO

    For each input node of snap no.  lenter a line
    of input containing input node number, input data
    value and chip to which this data enters.

    How many input nodes will you enter at this time?
2

    ENTER   2 LINES OF INPUT DATA AT THIS TIME
    (input node no.,data value,input chip no.)
1 -1 1
2 2 2

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         D   EXIT FROM EMUL
D
$ TYPE EXPCEL.TSF
XPERIMENT
  1
  7
  0
    1    -1     1
    2     2     2
    1     0     0
$ RUN EMUL

    THIS IS THE GENERAL PURPOSE ADAPTIVE ARRAY PROGRAM EMUL.  EMUL IS
    CAPABLE  OF  SIMULATING  A  COMMUNICATION  SYSTEM  HAVING RECEIVING
    ELEMENTS IN SPACE EXCITED BY A SIMULATED SCENARIO.  THE  SYSTEM  IS
    SPECIFIED  BY  THE  INTERCONNECTION  OF STANDARD COMPONENT BUILDING
    BLOCKS INTERCONNECTED AT NODES.

    SYSTEM AND TEST RUN PARAMETERS ARE SPECIFIED  BY  THE  USER  IN  AN
    INTERACTIVE DIALOG AND WRITTEN TO FILES.  THESE FILES ARE THEN USED
    TO SPECIFY SYSTEM CONFIGURATION AND TESTING MODE AT RUN TIME.

    THERE  ARE  THREE  TYPES  OF  ANSWERS  TO  QUESTIONS  USED  IN  THE
    INTERACTIVE  PROGRAM  CONSISTING  OF  YES  AND NO, MENU SELECT, AND
    PARAMETER SPECIFICATION.  ALL USER COMMANDS MUST BE TERMINATED BY A
    CARRIAGE RETURN ('<CR>').
```

```
    THERE ARE SEVERAL COMMANDS THAT WILL BE VALID AT ANY  TIME  THAT  A
    RESPONSE  FROM  YOU, THE USER, IS REQUIRED.  THESE COMMANDS CONSIST
    OF THE FOLLOWING:
         HELP-ADDITIONAL DETAILS ARE REQUESTED FOR QUESTION.
         EXIT-EXIT AFTER CLOSING FILES PRESENTLY BEING WRITTEN.
         BREAK-CLOSE FILES AND RETURN TO OPERATION SELECTION.

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         D   EXIT FROM EMUL
A
WHAT IS THE NAME OF THE INPUT EMU FILE?
EXPCEL.TSF
WHAT IS THE NAME OF THE OUTPUT FILE?
EXPCEL.OUT
WHAT IS THE NAME OF THE INPUT CHIP FILE?
EXPCEL.SSF
WHAT IS THE SPECIAL VISIBLE CHIP INPUT FILE
(ENTER 'NONE' IF THERE IS NONE)
(THE SPECIAL VISIBLE OUTPUT IS ALWAYS WRITTEN TO FILE 'SPVIS.OUT') ?
NONE
PULSING THE DATA...

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         D   EXIT FROM EMUL
D
$ TYPE EXPCEL.OUT
              *******THE SYSTOLIC EMULATOR HAS BEEN ACTIVATED*******

THE FOLLOWING INFORMATION REGARDING EACH ELEMENT HAS BEEN GIVEN TO THE EMULATOR

   CHIP NUMBER    INPUT NODES    OUTPUT NODE    CHIP OPERATION    CHIP CLOCK CYCLES
                    NUMBERS        NUMBER

         1          1    0          3          Delay (Time Shift)    1
         2          2    0          4          Delay (Time Shift)    1
         3          3    0          5          Delay (Time Shift)    0
         4          4    0          6          Delay (Time Shift)    0
         5          3    5          7          Multiplication        1
         6          4    6          8          Multiplication        1
         7          7    8          9          Addition              1


                    ***SNAPSHOT NUMBER  1  HAS BEGUN***
The fol lowing data has been accepted by the emulator for input as follows:
    Input Node Number       Actual Data Value
           1                    -1.00
           2                     2.00


    ELEMENTS HAVE BEEN GROUPED ACCORDING TO INPUT READINESS.
  PROCESSING ACCORDING TO SPECIFIED OPERATION CAN NOW BEGIN!
```

```
    SNAPSHOT   1SHALL NOW BEGIN
////////////////////////////////////////////////////////////


    Cycle   1 of snapshot  1 is ready to process
          2 elements will output data.
       These Chips are:
            1. Chip Number    1
               OUTPUT OF DELAY CHIP    1  IS  -1.00
               IT HAS A DELAYOF   1  CLOCK CYCLES
               OUTPUT OF CHIP    1  IS  -1.00

            2. Chip Number    2
               OUTPUT OF DELAY CHIP    2  IS   2.00
               IT HAS A DELAYOF   1  CLOCK CYCLES
               OUTPUT OF CHIP    2  IS   2.00

////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////


    Cycle   2 of snapshot  1 is ready to process
          4 elements will output data.
       These Chips are:
            1. Chip Number    3
               OUTPUT OF DELAY CHIP    3  IS  -1.00
               IT HAS A DELAYOF   0  CLOCK CYCLES
               OUTPUT OF CHIP    3  IS  -1.00

            2. Chip Number    4
               OUTPUT OF DELAY CHIP    4  IS   2.00
               IT HAS A DELAYOF   0  CLOCK CYCLES
               OUTPUT OF CHIP    4  IS   2.00

            3. Chip Number    5
                 -1.00    *  -1.00    =   1.00
               OUTPUT OF CHIP    5  IS   1.00

            4. Chip Number    6
                  2.00    *   2.00    =   4.00
               OUTPUT OF CHIP    6  IS   4.00

////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////


    Cycle   3 of snapshot  1 is ready to process
          1 elements will output data.
       These Chips are:
            1. Chip Number    7
                  1.00    +   4.00    =   5.00
               OUTPUT OF CHIP    7  IS   5.00
```

```
//////////////////////////////////////////////////////////////
//////////////////////////////////////////////////////////////

    ALL AVAILABLE INPUT DATA HAS BEEN READ.
                  THE EMULATOR WILL NOW BE DEACTIVATED
$ LOG
  SMITHR        logged out at 15-DEC-1989 10:24:03.95Connection closed by remote h
```

Appendix B

Interactive Example System Emulation File

```
        Welcome to VAX/VMS V5.1

Username: SMITHR
Password:
        Welcome to VAX/VMS version V5.1 on node MISVX1
    Last interactive login on Tuesday, 12-DEC-1989 15:34
●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●
 Lookup the phone number and office symbol of RADC personel, use the
 FIND command.
-------------------------------------------------------------------------------
 Send your MISVAX files to a LONEX printer, use the LP command.
-------------------------------------------------------------------------------
 To get information on special utilities installed on the 8650 cluster,
 type 'he p @RADC' at the $ prompt.
/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/>
$ RUN EMUL        SET DEF [SMITHR.                  DIR

Directory DC$DISK2:[SMITHR]

BOTH.DIR;1          EMUL.DIR;1          GADAR.DIR;1          INFO.DIR;1
LOGIN.COM;4         LOGIN.COM;3         LOGIN.COM;2          LOGIN.JOU;1
SYSTEM.DIR;1

Total of 9 files.
$ EM  SET DEF [EMUL]
$ DIR
%DIRECT-E-OPENIN, error opening DC$DISK2:[EMUL]*.*;* as input
-RMS-E-DNF, directory not found
-SYSTEM-W-NOSUCHFILE, no such file
$ SET DEF [SMITHR.EMUL]
$ DIR

Directory DC$DISK2:[SMITHR.EMUL]

ALGOR1.TSF;1        BACSUB.SSF;1        BACSUB.TSF;1         BNDCEL.SSF;1
BNDCEL.TSF;1        CACEL.SSF;1         CBACSB.SSF;1         CBNDC2.SSF;1
CBNDCL.SSF;1        CBNDCL.TSF;1        CCMCEL.SSF;1         CCOREL.SSF;1
CCOREL.TSF;1        CINTC2.SSF;1        CINTCL.SSF;1         CMCEL.SSF;1
CMULCL.SSF;1        CMULCL.TSF;1        CMXSOL.SSF;1         CMXSOL.TSF;1
COM.DIR;1           CORREL.SSF;1        CSMCEL.SSF;1         CSMI.OUT;1
CSMI.SSF;1          CSMI.TSF;1          CVDCEL.SSF;1         CVMCEL.SSF;1
EMUL.EXE;1          EXPCEL.OUT;1        EXPCEL.SSF;1         EXPCEL.TSF;1
FOR000.DAT;1        GIV2.SSF;1          GIV2.TSF;1           GIV3.SSF;1
GIV3.TSF;1          GIV4.SSF;1          IDTCEL.SSF;1         IDTCEL.TSF;1
INTCEL.SSF;1        INTCEL.TSF;1        MATSOL.SSF;1         SMI.SSF;1
SOURCE.DIR;1        SPVIS.OUT;1         TEST.DIR;1           WTCEL.SSF;1
WTCEL.TSF;1

Total of 49 files.
$ RUN EMUL

    THIS IS THE GENERAL PURPOSE ADAPTIVE ARRAY PROGRAM EMUL.  EMUL IS
    CAPABLE OF SIMULATING A COMMUNICATION SYSTEM HAVING RECEIVING
    ELEMENTS IN SPACE EXCITED BY A SIMULATED SCENARIO.  THE SYSTEM IS
    SPECIFIED BY THE INTERCONNECTION OF STANDARD COMPONENT BUILDING
    BLOCKS INTERCONNECTED AT NODES.

    SYSTEM AND TEST RUN PARAMETERS ARE SPECIFIED BY THE USER IN AN
```

```
    INTERACTIVE DIALOG AND WRITTEN TO FILES.  THESE FILES ARE THEN USED
    TO SPECIFY SYSTEM CONFIGURATION AND TESTING MODE AT RUN TIME.

    THERE ARE THREE TYPES OF ANSWERS TO QUESTIONS USED IN THE
    INTERACTIVE PROGRAM CONSISTING OF YES AND NO, MENU SELECT, AND
    PARAMETER SPECIFICATION.  ALL USER COMMANDS MUST BE TERMINATED BY A
    CARRIAGE RETURN ('<CR>').

    THERE ARE SEVERAL COMMANDS THAT WILL BE VALID AT ANY TIME THAT A
    RESPONSE FROM YOU, THE USER, IS REQUIRED.  THESE COMMANDS CONSIST
    OF THE FOLLOWING:
         HELP-ADDITIONAL DETAILS ARE REQUESTED FOR QUESTION.
         EXIT-EXIT AFTER CLOSING FILES PRESENTLY BEING WRITTEN.
         BREAK-CLOSE FILES AND RETURN TO OPERATION SELECTION.

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         D   EXIT FROM EMUL
B

    WHAT IS THE NAME OF THE CONFIGURATIN SPECIFICATION FILE
    TO BE OPENED FOR WRITING?
EXPSYS.SSF

    Select a component type for component      1.
         A   Cell (this is a heading for chips to then be specified)
         B   Add Chip
         C   Multiply Chip
         D   Delay Chip
         E   Look Up Chip
         F   quit (terminate structure entry)
D

    Component number      1 is of type:   DELY.  What is the one  input
    node number for this component?
1

    What is the output node number for this component?
101

    What numerical format is desired for this format?
         A   floating point
         B   fixed point
A

    Should the component be 16 bit or 32 bit?
         A   16
         B   32
B

    How many clock cycles is this chip?
0

    The following parameters have been specified for component      1 of
    type  DELY.  Do you wish to change anything?  (yes or no)
         First input node:       1
         Output node:     101
         Numerical format:    FLOT
```

```
          16 bit or 32 bit size:      32
          Clock cycle(s):       0
NO

     Select a component type for component      2.
          A    Cell (this is a heading for chips to then be specified)
          B    Add Chip
          C    Multiply Chip
          D    Delay Chip
          E    Look Up Chip
          F    quit (terminate structure entry)
D

     Component number      2 is of type:   DELY.  What is the one  input
     node number for this component?
2

     What is the output node number for this component?
101 2

     What numerical format is desired for this format?
          A    floating point
          B    fixed point
A

     Should the component be 16 bit or 32 bit?
          A    16
          B    32
B

     How many clock cycles is this chip?
0

     The following parameters have been specified for component      2 of
     type  DELY.  Do you wish to change anything?  (yes or no)
          First input node:       2
          Output node:     102
          Numerical format:    FLOT
          16 bit or 32 bit size:      32
          Clock cycle(s):       0
NO

     Select a component type for component      3.
          A    Cell (this is a heading for chips to then be specified)
          B    Add Chip
          C    Multiply Chip
          D    Delay Chip
          E    Look Up Chip
          F    quit (terminate structure entry)
D

     Component number      3 is of type:   DELY.  What is the one  input
     node number for this component?
3

     What is the output node number for this component?
201

     What numerical format is desired for this format?
          A    floating point
```

```
        B   fixed point
A

    Should the component be 16 bit or 32 bit?
        A   16
        B   32
B

    How many clock cycles is this chip?
0

    The following parameters have been specified for component     3 of
    type  DELY.  Do you wish to change anything?  (yes or no)
        First input node:      3
        Output node:    201
        Numerical format:   FLOT
        16 bit or 32 bit size:     32
        Clock cycle(s):      0
NO

    Select a component type for component     4.
        A   Cell (this is a heading for chips to then be specified)
        B   Add Chip
        C   Multiply Chip
        D   Delay Chip
        E   Look Up Chip
        F   quit (terminate structure entry)
D

    Component number     4 is of type:   DELY.  What is the one  input
    node number for this component?
4

    What is the output node number for this component?
202

    What numerical format is desired for this format?
        A   floating point
        B   fixed point
A

    Should the component be 16 bit or 32 bit?
        A   16
        B   32
B

    How many clock cycles is this chip?
0

    The following parameters have been specified for component     4 of
    type  DELY.  Do you wish to change anything?  (yes or no)
        First input node:      4
        Output node:    202
        Numerical format:   FLOT
        16 bit or 32 bit size:     32
        Clock cycle(s):      0
NO

    Select a component type for component     5.
        A   Cell (this is a heading for chips to then be specified)
```

```
        B   Add Chip
        C   Multiply Chip
        D   Delay Chip
        E   Look Up Chip
        F   quit (terminate structure entry)
D

    Component number     5 is of type:   DELY.  What is the one  input
    node number for this component?
109

    What is the output node number for this component?
5

    What numerical format is desired for this format?
        A   floating point
        B   fixed point
A

    Should the component be 16 bit or 32 bit?
        A   16
        B   32
B

    How many clock cycles is this chip?
1

    The following parameters have been specified for component     5 of
    type  DELY.  Do you wish to change anything?  (yes or no)
        First input node:     109
        Output node:        5
        Numerical format:    FLOT
        16 bit or 32 bit size:      32
        Clock cycle(s):       1
NO

    Select a component type for component     6.
        A   Cell (this is a heading for chips to then be specified)
        B   Add Chip
        C   Multiply Chip
        D   Delay Chip
        E   Look Up Chip
        F   quit (terminate structure entry)
E

    Component number     6 is of type:   LOOK.  What is the one  input
    node number for this component?
209

    What is the output node number for this component?
6

    What numerical format is desired for this format?
        A   floating point
        B   fixed point
A

    Should the component be 16 bit or 32 bit?
        A   16
        B   32
```

```
B

    How many clock cycles is this chip?
1

    The following parameters have been specified for component     6 of
    type  LOOK.  Do you wish to change anything?  (yes or no)
         First input node:     209
         Output node:       6
         Numerical format:    FLOT
         16 bit or 32 bit size:      32
         Clock Cycle(s):       1
NO

    Select a component type for component      7.
         A   Cell (this is a heading for chips to then be specified)
         B   Add Chip
         C   Multiply Chip
         D   Delay Chip
         E   Look Up Chip
         F   quit (terminate structure entry)
C

    Component number      7 is of type:    MULT.  What is input node
    number     1for this component?
5

    Component number      7 is of type:    MULT.  What is input node
    number     2for this component?
6

    What is the output node number for this component?
7

    What numerical format is desired for this format?
         A   floating point
         B   fixed point
A

    Should the component be 16 bit or 32 bit?
         A   16
         B   32
B

    How many clock cycles is this chip?
1

    The following parameters have been specified for component     7 of
    type  MULT.  Do you wish to change anything?  (yes or nc)
         First input node:       5
         Second input node:       6
         Output node:       7
         Numerical format:    FLOT
         16 bit or 32 bit size:      32
         Clock Cycle(s):       1
NC

    Select a component type for component      8.
         A   Cell (this is a heading for chips to then be specified)
         B   Add Chip
```

```
        C   Multiply Chip
        D   Delay Chip
        E   Look Up Chip
        F   quit (terminate structure entry)
A

    Enter the number of input nodes of this cell.
2

    Enter the number of output nodes of the cell.
1

    Enter the number of chips in cell.
7

    Do you wish to change anything for this cell?(y or n)
    Number of input nodes:    2
    Number of output nodes:    1
    Number of chips in cell:    7
NO

    Select a component type for component     9.
        A   Cell (this is a heading for chips to then be specified)
        B   Add Chip
        C   Multiply Chip
        D   Delay Chip
        E   Look Up Chip
        F   quit (terminate structure entry)
D

    Component number     9 is of type:   DELY.  What is the one  input
    node number for this component?
1

    What is the output node number for this component?
3

    What numerical format is desired for this format?
        A   floating point
        B   fixed point
A

    Should the component be 16 bit or 32 bit?
        A   16
        B   32
B

    How many clock cycles is this chip?
1

    The following parameters have been specified for component     9 of
    type  DELY.  Do you wish to change anything?  (yes or no)
        First input node:      1
        Output node:      3
        Numerical format:   FLOT
        16 bit or 32 bit size:     32
        Clock cycle(s):      1
NO

    Select a component type for component    10.
```

```
          A   Cell (this is a heading for chips to then be specified)
          B   Add Chip
          C   Multiply Chip
          D   Delay Chip
          E   Look Up Chip
          F   quit (terminate structure entry)
D

     Component number    10 is of type:   DELY.  What is the one  input
     node number for this component?
2

     What is the output node number for this component?
4

     What numerical format is desired for this format?
          A   floating point
          B   fixed point
A

     Should the component be 16 bit or 32 bit?
          A   16
          B   32
B

     How many clock cycles is this chip?
1

     The following parameters have been specified for component    10 of
     type  DELY.  Do you wish to change anything?  (yes or no)
          First input node:      2
          Output node:      4
          Numerical format:   FLOT
          16 bit or 32 bit size:     32
          Clock cycle(s):      1
NO

     Select a component type for component    11.
          A   Cell (this is a heading for chips to then be specified)
          B   Add Chip
          C   Multiply Chip
          D   Delay Chip
          E   Look Up Chip
          F   quit (terminate structure entry)
D

     Component number    11 is of type:   DELY.  What is the one  input
     node number for this component?
3

     What is the output node number for this component?
5

     What numerical format is desired for this format?
          A   floating point
          B   fixed point
A

     Should the component be 16 bit or 32 bit?
          A   16
```

```
          B   32
B

     How many clock cycles is this chip?
0

     The following parameters have been specified for component    11 of
     type  DELY.  Do you wish to change anything?  (yes or no)
          First input node:      3
          Output node:      5
          Numerical format:   FLOT
          16 bit or 32 bit size:     32
          Clock cycle(s):      0
NO

     Select a component type for component    12.
          A   Cell (this is a heading for chips to then be specified)
          B   Add Chip
          C   Multiply Chip
          D   Delay Chip
          E   Lock Up Chip
          F   quit (terminate structure entry)
D

     Component number    12 is of type:   DELY.  What is the one  input
     node number for this component?
4

     What is the output node number for this component?
6

     What numerical format is desired for this format?
          A   floating point
          B   fixed point
A

     Should the component be 16 bit or 32 bit?
          A   16
          B   32
B

     How many clock cycles is this chip?
0

     The following parameters have been specified for component    12 of
     type  DELY.  Do you wish to change anything?  (yes or no)
          First input node:      4
          Output node:      6
          Numerical format:   FLOT
          16 bit or 32 bit size:     32
          Clock cycle(s):      0
NO

     Select a component type for component    13.
          A   Cell (this is a heading for chips to then be specified)
          B   Add Chip
          C   Multiply Chip
          D   Delay Chip
          E   Lock Up Chip
          F   quit (terminate structure entry)
```

```
C

    Component number    13 is of type:   MULT.  What is input node
    number    1for this component?
3

    Component number    13 is of type:   MULT.  What is input node
    number    2for this component?
5

    What is the output node number for this component?
7

    What numerical format is desired for this format?
         A   floating point
         B   fixed point
A

    Should the component be 16 bit or 32 bit?
         A   16
         B   32
B

    How many clock cycles is this chip?
1

    The following parameters have been specified for component    13 of
    type  MULT.  Do you wish to change anything?  (yes or no)
         First input node:      3
         Second input node:      5
         Output node:      7
         Numerical format:   FLOT
         16 bit or 32 bit size:     32
         Clock Cycle(s):      1
NO

    Select a component type for component    14.
         A   Cell (this is a heading for chips to then be specified)
         B   Add Chip
         C   Multiply Chip
         D   Delay Chip
         E   Look Up Chip
         F   quit (terminate structure entry)
C

    Component number    14 is of type:   MULT.  What is input node
    number    1for this component?
4

    Component number    14 is of type:   MULT.  What is input node
    number    2for this component?
6

    What is the output node number for this component?
8

    What numerical format is desired for this format?
         A   floating point
         B   fixed point
A
```

```
    Should the component be 16 bit or 32 bit?
         A   16
         B   32
B

    How many clock cycles is this chip?
1

    The following parameters have been specified for component    14 of
    type  MULT.  Do you wish to change anything?  (yes or no)
         First input node:      4
         Second input node:      6
         Output node:      8
         Numerical format:   FLOT
         16 bit or 32 bit size:     32
         Clock Cycle(s):      1
NO

    Select a component type for component    15.
         A   Cell (this is a heading for chips to then be specified)
         B   Add Chip
         C   Multiply Chip
         D   Delay Chip
         E   Look Up Chip
         F   quit (terminate structure entry)
B

    Component number    15 is of type:   ADDR.  What is input node
    number    1for this component?
7

    Component number    15 is of type:   ADDR.  What is input node
    number    2for this component?
8

    What is the output node number for this component?
9

    What numerical format is desired for this format?
         A   floating point
         B   fixed point
A

    Should the component be 16 bit or 32 bit?
         A   16
         B   32
B

    How many clock cycles is this chip?
1

    The following parameters have been specified for component    15 of
    type  ADDR.  Do you wish to change anything?  (yes or no)
         First input node:      7
         Second input node:      8
         Output node:      9
         Numerical format:   FLOT
         16 bit or 32 bit size:     32
         Clock Cycle(s):      1
```

```
NO

    Select a component type for component    16.
         A   Cell (this is a heading for chips to then be specified)
         B   Add Chip
         C   Multiply Chip
         D   Delay Chip
         E   Look Up Chip
         F   quit (terminate structure entry)
A

    Enter the number of input nodes of this cell.
2

    Enter the number of output nodes of the cell.
1

    Enter the number of chips in cell.
7

    Do you wish to change anything for this cell?(y or n)
    Number of input nodes:    2
    Number of output nodes:    1
    Number of chips in cell:    7
NO

    Select a component type for component    17.
         A   Cell (this is a heading for chips to then be specified)
         B   Add Chip
         C   Multiply Chip
         D   Delay Chip
         E   Look Up Chip
         F   quit (terminate structure entry)
D

    Component number    17 is of type:   DELY.  What is the one  input
    node number for this component?
1

    What is the output node number for this component?
3

    What numerical format is desired for this format?
         A   floating point
         B   fixed point
A

    Should the component be 16 bit or 32 bit?
         A   16
         B   32
B

    How many clock cycles is this chip?
1

    The following parameters have been specified for component    17 of
    type  DELY.  Do you wish to change anything?  (yes or no)
         First input node:      1
         Output node:      3
         Numerical format:   FLOT
```

```
        16 bit or 32 bit size:      32
        Clock cycle(s):       1
NO

    Select a component type for component     18.
        A   Cell (this is a heading for chips to then be specified)
        B   Add Chip
        C   Multiply Chip
        D   Delay Chip
        E   Look Up Chip
        F   quit (terminate structure entry)
D

    Component number     18 is of type:   DELY.  What is the one  input
    node number for this component?
2

    What is the output node number for this component?
4

    What numerical format is desired for this format?
        A   floating point
        B   fixed point
A

    Should the component be 16 bit or 32 bit?
        A   16
        B   32
B

    How many clock cycles is this chip?
1

    The following parameters have been specified for component     18 of
    type  DELY.  Do you wish to change anything?  (yes or no)
        First input node:       2
        Output node:       4
        Numerical format:   FLOT
        16 bit or 32 bit size:      32
        Clock cycle(s):       1
NO

    Select a component type for component     19.
        A   Cell (this is a heading for chips to then be specified)
        B   Add Chip
        C   Multiply Chip
        D   Delay Chip
        E   Look Up Chip
        F   quit (terminate structure entry)
D

    Component number     19 is of type:   DELY.  What is the one  input
    node number for this component?
3

    What is the output node number for this component?
5

    What numerical format is desired for this format?
        A   floating point
```

```
        B   fixed point
A

    Should the component be 16 bit or 32 bit?
        A   16
        B   32
B

    How many clock cycles is this chip?
0

    The following parameters have been specified for component    19 of
    type  DELY.  Do you wish to change anything?  (yes or no)
        First input node:       3
        Output node:        5
        Numerical format:   FLOT
        16 bit or 32 bit size:      32
        Clock cycle(s):       0
NO

    Select a component type for component    20.
        A   Cell (this is a heading for chips to then be specified)
        B   Add Chip
        C   Multiply Chip
        D   Delay Chip
        E   Look Up Chip
        F   quit (terminate structure entry)
D

    Component number    20 is of type:   DELY.  What is the one input
    node number for this component?
4

    What is the output node number for this component?
6

    What numerical format is desired for this format?
        A   floating point
        B   fixed point
A

    Should the component be 16 bit or 32 bit?
        A   16
        B   32
B

    How many clock cycles is this chip?
0

    The following parameters have been specified for component    20 of
    type  DELY.  Do you wish to change anything?  (yes or no)
        First input node:       4
        Output node:        6
        Numerical format:   FLOT
        16 bit or 32 bit size:      32
        Clock cycle(s):       0
NO

    Select a component type for component    21.
        A   Cell (this is a heading for chips to then be specified)
```

```
          B   Add Chip
          C   Multiply Chip
          D   Delay Chip
          E   Look Up Chip
          F   quit (terminate structure entry)
C

     Component number    21 is of type:   MULT.  What is input node
     number    1for this component?
3

     Component number    21 is of type:   MULT.  What is input node
     number    2for this component?
5

     What is the output node number for this component?
7

     What numerical format is desired for this format?
          A   floating point
          B   fixed point
A

     Should the component be 16 bit or 32 bit?
          A   16
          B   32
B

     How many clock cycles is this chip?
1

     The following parameters have been specified for component    21 of
     type  MULT.  Do you wish to change anything?  (yes or no)
          First input node:      3
          Second input node:      5
          Output node:      7
          Numerical format:   FLOT
          16 bit or 32 bit size:     32
          Clock Cycle(s):      1
NO

     Select a component type for component    22.
          A   Cell (this is a heading for chips to then be specified)
          B   Add Chip
          C   Multiply Chip
          D   Delay Chip
          E   Look Up Chip
          F   quit (terminate structure entry)
C

     Component number    22 is of type:   MULT.  What is input node
     number    1for this component?
4

     Component number    22 is of type:   MULT.  What is input node
     number    2for this component?
6

     What is the output node number for this component?
8
```

```
    What numerical format is desired for this format?
         A   floating point
         B   fixed point
A

    Should the component be 16 bit or 32 bit?
         A   16
         B   32
B

    How many clock cycles is this chip?
1

    The following parameters have been specified for component    22 of
    type  MULT.  Do you wish to change anything?  (yes or no)
         First input node:      4
         Second input node:      6
         Output node:      8
         Numerical format:   FLOT
         16 bit or 32 bit size:     32
         Clock Cycle(s):      1
NO

    Select a component type for component    23.
         A   Cell (this is a heading for chips to then be specified)
         B   Add Chip
         C   Multiply Chip
         D   Delay Chip
         E   Look Up Chip
         F   quit (terminate structure entry)
B

    Component number    23 is of type:   ADDR.  What is input node
    number    1for this component?
7

    Component number    23 is of type:   ADDR.  What is input node
    number    2for this component?
8

    What is the output node number for this component?
9

    What numerical format is desired for this format?
         A   floating point
         B   fixed point
A

    Should the component be 16 bit or 32 bit?
         A   16
         B   32
B

    How many clock cycles is this chip?
1

    The following parameters have been specified for component    23 of
    type  ADDR.  Do you wish to change anything?  (yes or no)
         First input node:      7
```

```
          Second input node:      8
          Output node:      9
          Numerical format:   FLOT
          16 bit or 32 bit size:     32
          Clock Cycle(s):      1
NO

     Select a component type for component    24.
          A   Cell (this is a heading for chips to then be specified)
          B   Add Chip
          C   Multiply Chip
          D   Delay Chip
          E   Look Up Chip
          F   quit (terminate structure entry)
F

     AT THIS TIME, DO YOU WANT TO:
          A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
          B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
          C   GENERATE A NEW TEST RUN SPECIFICATION FILE.
          D   EXIT FROM EMUL
D
$ TYPE EXPSYS.SSF
ONFIGURATIN
     1     0   101    FLOT    DELY     32     0
     2     0   102    FLOT    DELY     32     0
     3     0   201    FLOT    DELY     32     0
     4     0   202    FLOT    DELY     32     0
   109     0     5    FLOT    DELY     32     1
   209     0     6    FLOT    LOOK     32     1
     5     6     7    FLOT    MULT     32     1
    2     1     7
     1     0     3    FLOT    DELY     32     1
     2     0     4    FLOT    DELY     32     1
     3     0     5    FLOT    DELY     32     0
     4     0     6    FLOT    DELY     32     0
     3     5     7    FLOT    MULT     32     1
     4     6     8    FLOT    MULT     32     1
     7     8     9    FLOT    ADDR     32     1
    2     1     7
     1     0     3    FLOT    DELY     32     1
     2     0     4    FLOT    DELY     32     1
     3     0     5    FLOT    DELY     32     0
     4     0     6    FLOT    DELY     32     0
     3     5     7    FLOT    MULT     32     1
     4     6     8    FLOT    MULT     32     1
     7     8     9    FLOT    ADDR     32     1
$ RUN EMUL

     THIS IS THE GENERAL PURPOSE ADAPTIVE ARRAY PROGRAM EMUL.  EMUL IS
     CAPABLE OF SIMULATING A COMMUNICATION SYSTEM HAVING RECEIVING
     ELEMENTS IN SPACE EXCITED BY A SIMULATED SCENARIO.  THE SYSTEM IS
     SPECIFIED BY THE INTERCONNECTION OF STANDARD COMPONENT BUILDING
     BLOCKS INTERCONNECTED AT NODES.

     SYSTEM AND TEST RUN PARAMETERS ARE SPECIFIED BY THE USER IN AN
     INTERACTIVE DIALOG AND WRITTEN TO FILES.  THESE FILES ARE THEN USED
     TO SPECIFY SYSTEM CONFIGURATION AND TESTING MODE AT RUN TIME.

     THERE ARE THREE TYPES OF ANSWERS TO QUESTIONS USED IN THE
```

```
    INTERACTIVE PROGRAM CONSISTING OF YES AND NO, MENU SELECT, AND
    PARAMETER SPECIFICATION.  ALL USER COMMANDS MUST BE TERMINATED BY A
    CARRIAGE RETURN ('<CR>').

    THERE ARE SEVERAL COMMANDS THAT WILL BE VALID AT ANY TIME THAT A
    RESPONSE FROM YOU, THE USER, IS REQUIRED.  THESE COMMANDS CONSIST
    OF THE FOLLOWING:
         HELP-ADDITIONAL DETAILS ARE REQUESTED FOR QUESTION.
         EXIT-EXIT AFTER CLOSING FILES PRESENTLY BEING WRITTEN.
         BREAK-CLOSE FILES AND RETURN TO OPERATION SELECTION.

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         D   EXIT FROM EMUL
C

    WHAT IS THE NAME OF THE EXPERIMENT   SPECIFICATION FILE
    TO BE OPENED FOR WRITING?
EXPSYS.TSF

    At this time EMUL requires a general knowledge of the system that
    will now be tested.  How many input snapshots of the input data do
    you want to process?
1

    What are the total number of chips in the system you are
    specifying, that are not located within a cell?
7

    What are the total number of cells in the array processor?
2

    The following parameters have been specified for this system.  Do you wish t
o change anything?(yes or no)
         Number of snapshots:     1
         Number of chips:     7
         Number of cells:     2
NO

    For each input node of snap no.  1enter a line
    of input containing input node number, input data
    value and chip to which this data enters.

    How many input nodes will you enter at this time?
4

    ENTER   4 LINES OF INPUT DATA AT THIS TIME
    (input node no.,data value,input chip no.)
1 1 1
2 2 2
3 3 3
4 4 4

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         D   EXIT FROM EMUL
```

```
D
$ TYPE EXPSYS.TSF
XPERIMENT
  1
  7
  2
    1      1      1
    2      2      2
    3      3      3
    4      4      4
    1      0      0
$ RUN EMUL

    THIS IS THE GENERAL PURPOSE ADAPTIVE ARRAY PROGRAM EMUL.  EMUL IS
    CAPABLE OF SIMULATING A COMMUNICATION SYSTEM HAVING RECEIVING
    ELEMENTS IN SPACE EXCITED BY A SIMULATED SCENARIO.  THE SYSTEM IS
    SPECIFIED BY THE INTERCONNECTION OF STANDARD COMPONENT BUILDING
    BLOCKS INTERCONNECTED AT NODES.

    SYSTEM AND TEST RUN PARAMETERS ARE SPECIFIED BY THE USER IN AN
    INTERACTIVE DIALOG AND WRITTEN TO FILES.  THESE FILES ARE THEN USED
    TO SPECIFY SYSTEM CONFIGURATION AND TESTING MODE AT RUN TIME.

    THERE ARE THREE TYPES OF ANSWERS TO QUESTIONS USED IN THE
    INTERACTIVE PROGRAM CONSISTING OF YES AND NO, MENU SELECT, AND
    PARAMETER SPECIFICATION.  ALL USER COMMANDS MUST BE TERMINATED BY A
    CARRIAGE RETURN ('<CR>').

    THERE ARE SEVERAL COMMANDS THAT WILL BE VALID AT ANY TIME THAT A
    RESPONSE FROM YOU, THE USER, IS REQUIRED.  THESE COMMANDS CONSIST
    OF THE FOLLOWING:
         HELP-ADDITIONAL DETAILS ARE REQUESTED FOR QUESTION.
         EXIT-EXIT AFTER CLOSING FILES PRESENTLY BEING WRITTEN.
         BREAK-CLOSE FILES AND RETURN TO OPERATION SELECTION.

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         D   EXIT FROM EMUL
A
WHAT IS THE NAME OF THE INPUT EMU FILE?
EXPSYS.TSF
WHAT IS THE NAME OF THE OUTPUT FILE?
EXPSYS.OUT
WHAT IS THE NAME OF THE INPUT CHIP FILE?
EXPSYS.SSF
WHAT IS THE SPECIAL VISIBLE CHIP INPUT FILE
(ENTER 'NONE' IF THERE IS NONE)
(THE SPECIAL VISIBLE OUTPUT IS ALWAYS WRITTEN TO FILE 'SPVIS.OUT') ?
NONE
PULSING THE DATA...

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         D   EXIT FROM EMUL
D
$ TYPE EXPSYS.OUT
```

```
*******THE SYSTOLIC EMULATOR HAS BEEN ACTIVATED*******

THE FOLLOWING INFORMATION REGARDING EACH ELEMENT HAS BEEN GIVEN TO THE EMULATOR

   CHIP NUMBER    INPUT NODES NUMBERS    OUTPUT NODE NUMBER    CHIP OPERATION    CHIP CLOCK CYCLES

         1          1     0              101          Delay (Time Shift)    0
         2          2     0              102          Delay (Time Shift)    0
         3          3     0              201          Delay (Time Shift)    0
         4          4     0              202          Delay (Time Shift)    0
         5        109     0                5          Delay (Time Shift)    1
         6        209     0                6    Look Up: Sq Root Recip.     1
         7          5     6                7          Multiplication        1

                  ***SNAPSHOT NUMBER  1  HAS BEGUN***
The fol lowing data has been accepted by the emulator for input as follows:
    Input Node Number        Actual Data Value
          1                      1.00
          2                      2.00
          3                      3.00
          4                      4.00
      101          1     0          3          Delay (Time Shift)    1
      102          2     0          4          Delay (Time Shift)    1
      103          3     0          5          Delay (Time Shift)    0
      104          4     0          6          Delay (Time Shift)    0
      105          3     5          7          Multiplication        1
      106          4     6          8          Multiplication        1
      107          7     8          9          Addition              1
      201          1     0          3          Delay (Time Shift)    1
      202          2     0          4          Delay (Time Shift)    1
      203          3     0          5          Delay (Time Shift)    0
      204          4     0          6          Delay (Time Shift)    0
      205          3     5          7          Multiplication        1
      206          4     6          8          Multiplication        1
      207          7     8          9          Addition              1


   ELEMENTS HAVE BEEN GROUPED ACCORDING TO INPUT READINESS.
 PROCESSING ACCORDING TO SPECIFIED OPERATION CAN NOW BEGIN!


   SNAPSHOT   1SHALL NOW BEGIN
////////////////////////////////////////////////////////////


   Cycle   1 of snapshot  1 is ready to process
        8 elements will output data.
     These Chips are:
          1. Chip Number    1
             OUTPUT OF DELAY CHIP    1  IS   1.00
             IT HAS A DELAYOF   0  CLOCK CYCLES
             OUTPUT OF CHIP    1  IS   1.00

          2. Chip Number    2
             OUTPUT OF DELAY CHIP    2  IS   2.00
```

```
        IT HAS A DELAYOF    0  CLOCK CYCLES
        OUTPUT OF CHIP    2  IS    2.00

    3. Chip Number    3
        OUTPUT OF DELAY CHIP    3  IS    3.00
        IT HAS A DELAYOF    0  CLOCK CYCLES
        OUTPUT OF CHIP    3  IS    3.00

    4. Chip Number    4
        OUTPUT OF DELAY CHIP    4  IS    4.00
        IT HAS A DELAYOF    0  CLOCK CYCLES
        OUTPUT OF CHIP    4  IS    4.00

    5. Chip Number  101
        OUTPUT OF DELAY CHIP  101  IS    1.00
        IT HAS A DELAYOF    1  CLOCK CYCLES
        OUTPUT OF CHIP  101  IS    1.00

    6. Chip Number  102
        OUTPUT OF DELAY CHIP  102  IS    2.00
        IT HAS A DELAYOF    1  CLOCK CYCLES
        OUTPUT OF CHIP  102  IS    2.00

    7. Chip Number  201
        OUTPUT OF DELAY CHIP  201  IS    3.00
        IT HAS A DELAYOF    1  CLOCK CYCLES
        OUTPUT OF CHIP  201  IS    3.00

    8. Chip Number  202
        OUTPUT OF DELAY CHIP  202  IS    4.00
        IT HAS A DELAYOF    1  CLOCK CYCLES
        OUTPUT OF CHIP  202  IS    4.00

////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////


Cycle   2 of snapshot  1 is ready to process
      8 elements will output data.
   These Chips are:
      1. Chip Number  103
          OUTPUT OF DELAY CHIP  103  IS    1.00
          IT HAS A DELAYOF    0  CLOCK CYCLES
          OUTPUT OF CHIP  103  IS    1.00

      2. Chip Number  104
          OUTPUT OF DELAY CHIP  104  IS    2.00
          IT HAS A DELAYOF    0  CLOCK CYCLES
          OUTPUT OF CHIP  104  IS    2.00

      3. Chip Number  203
          OUTPUT OF DELAY CHIP  203  IS    3.00
          IT HAS A DELAYOF    0  CLOCK CYCLES
          OUTPUT OF CHIP  203  IS    3.00

      4. Chip Number  204
          OUTPUT OF DELAY CHIP  204  IS    4.00
          IT HAS A DELAYOF    0  CLOCK CYCLES
```

```
            OUTPUT OF CHIP  204  IS   4.00

        5. Chip Number  105
              1.00    *   1.00    =   1.00
            OUTPUT OF CHIP  105  IS   1.00

        6. Chip Number  106
              2.00    *   2.00    =   4.00
            OUTPUT OF CHIP  106  IS   4.00

        7. Chip Number  205
              3.00    *   3.00    =   9.00
            OUTPUT OF CHIP  205  IS   9.00

        8. Chip Number  206
              4.00    *   4.00    =   16.0
            OUTPUT OF CHIP  206  IS   16.0

////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////


    Cycle   3 of snapshot  1 is ready to process
          2 elements will output data.
       These Chips are:
          1. Chip Number  107
              1.00    +   4.00    =   5.00
            OUTPUT OF CHIP  107  IS   5.00

          2. Chip Number  207
              9.00    +   16.0    =   25.0
            OUTPUT OF CHIP  207  IS   25.0

////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////


    Cycle   4 of snapshot  1 is ready to process
          2 elements will output data.
       These Chips are:
          1. Chip Number    5
            OUTPUT OF DELAY CHIP    5  IS   5.00
            IT HAS A DELAYOF   1  CLOCK CYCLES
            OUTPUT OF CHIP    5  IS   5.00

          2. Chip Number    6
            OUTPUT OF CHIP    6  IS  0.200

////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////


    Cycle   5 of snapshot  1 is ready to process
          1 elements will output data.
```

```
        These Chips are:
             1. Chip Number    7
                   5.00    *  0.200    =   1.00
                OUTPUT OF CHIP    7  IS   1.00

////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////


    ALL AVAILABLE INPUT DATA HAS BEEN READ.
                  THE EMULATOR WILL NOW BE DEACTIVATED
$ LP EXPSYS.SSF
$ LP EXPSYS.TSF
$ LP EXPSYS.OUT
$ LOG
  SMITHR       logged out at 13-DEC-1989 08:28:52.95Connection closed by remote
```

Appendix C

Interactive Element Feedback Example Emulation File

```
        Welcome to VAX/VMS V5.1

Username: SMITHR
Password:
        Welcome to VAX/VMS version V5.1 on node MISVX1
    Last interactive login on Friday, 15-DEC-1989 10:14Z>
*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*
 Lookup the phone number and office symbol of RADC personel, use the
 FIND command.
-------------------------------------------------------------------------------
 Send your MISVAX files to a LONEX printer, use the LP command.
-------------------------------------------------------------------------------
 To get information on special utilities installed on the 8650 cluster,
 type 'help @RADC' at the $ prompt.
/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/>
$ DIR

Directory DC$DISK2:[SMITHR]

BOTH.DIR;1          EMUL.DIR;1          GADAR.DIR;1         INFO.DIR;1
LOGIN.COM;4         LOGIN.COM;3         LOGIN.COM;2         LOGIN.JOU;1
SYSTEM.DIR;1

Total of 9 files.
$ SET DEF DM  [SMITHR.EMUL]
$ DIR

Directory DC$DISK2:[SMITHR.EMUL]

ALGOR1.TSF;1        BACSUB.SSF;1        BACSUB.TSF;1        BNDCEL.SSF;1
BNDCEL.TSF;1        CACEL.SSF;1         CBACSB.SSF;1        CBNDC2.SSF;1
CBNDCL.SSF;1        CBNDCL.TSF;1        CCMCEL.SSF;1        CCOREL.SSF;1
CCOREL.TSF;1        CINTC2.SSF;1        CINTCL.SSF;1        CMCEL.SSF;1
CMULCL.SSF;1        CMULCL.TSF;1        CMXSOL.SSF;1        CMXSOL.TSF;1
COM.DIR;1           CORREL.SSF;1        CSMCEL.SSF;1        CSMI.SSF;1
CSMI.TSF;1          CVDCEL.SSF;1        CVMCEL.SSF;1        EMUL.EXE;1
EXPCEL.OUT;1        EXPCEL.SSF;1        EXPCEL.TSF;1        FOR000.DAT;1
GIV2.SSF;1          GIV2.TSF;1          GIV3.SSF;1          GIV3.TSF;1
GIV4.SSF;1          IDTCEL.SSF;1        IDTCEL.TSF;1        INTCEL.SSF;1
INTCEL.TSF;1        MATSOL.SSF;1        SMI.SSF;1           SOURCE.DIR;1
SPVIS.OUT;1         TEST.DIR;1          WTCEL.SSF;1         WTCEL.TSF;1

Total of 48 files.
$ RUN EMUL

    THIS IS THE GENERAL PURPOSE ADAPTIVE ARRAY PROGRAM EMUL.  EMUL IS
    CAPABLE OF SIMULATING A COMMUNICATION SYSTEM HAVING RECEIVING
    ELEMENTS IN SPACE EXCITED BY A SIMULATED SCENARIO.  THE SYSTEM IS
    SPECIFIED BY THE INTERCONNECTION OF STANDARD COMPONENT BUILDING
    BLOCKS INTERCONNECTED AT NODES.

    SYSTEM AND TEST RUN PARAMETERS ARE SPECIFIED BY THE USER IN AN
    INTERACTIVE DIALOG AND WRITTEN TO FILES.  THESE FILES ARE THEN USED
    TO SPECIFY SYSTEM CONFIGURATION AND TESTING MODE AT RUN TIME.

    THERE ARE THREE TYPES OF ANSWERS TO QUESTIONS USED IN THE
    INTERACTIVE PROGRAM CONSISTING OF YES AND NO, MENU SELECT, AND
    PARAMETER SPECIFICATION.  ALL USER COMMANDS MUST BE TERMINATED BY A
```

```
    CARRIAGE RETURN ('<CR>').

    THERE ARE SEVERAL COMMANDS THAT WILL BE VALID AT ANY  TIME  THAT  A
    RESPONSE  FROM  YOU, THE USER, IS REQUIRED.  THESE COMMANDS CONSIST
    OF THE FOLLOWING:
         HELP-ADDITIONAL DETAILS ARE REQUESTED FOR QUESTION.
         EXIT-EXIT AFTER CLOSING FILES PRESENTLY BEING WRITTEN.
         BREAK-CLOSE FILES AND RETURN TO OPERATION SELECTION.

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         D   EXIT FROM EMUL
B

    WHAT IS THE NAME OF THE CONFIGURATIN SPECIFICATION FILE
    TO BE OPENED FOR WRITING?
FEDBAK.SSF

    Select a component type for component     1.
         A   Cell (this is a heading for chips to then be specified)
         B   Add Chip
         C   Multiply Chip
         D   Delay Chip
         E   Look Up Chip
         F   quit (terminate structure entry)
B

    Component number     1 is of type:   ADDR.  What is input node
    number    1for this component?
1

    Component number     1 is of type:   ADDR.  What is input node
    number    2for this component?
2

    What is the output node number for this component?
2

    What numerical format is desired for this format?
         A   floating point
         B   fixed point
A

    Should the component be 16 bit or 32 bit?
         A   16
         B   32
B

    How many clock cycles is this chip?
1

    The following parameters have been specified for component     1 of
    type  ADDR.  Do you wish to change anything?  (yes or no)
         First input node:      1
         Second input node:      2
         Output node:      2
         Numerical format:   FLOT
         16 bit or 32 bit size:     32
```

```
        Clock Cycle(s):      1
NO

    Select a component type for component     2.
         A   Cell (this is a heading for chips to then be specified)
         B   Add Chip
         C   Multiply Chip
         D   Delay Chip
         E   Look Up Chip
         F   quit (terminate structure entry)
F

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         D   EXIT FROM EMUL
D
$ TYPE FEDBAK.SSF
ONFIGURATIN
    1    2    2   FLOT   ADDR    32    1
$ RUN EMUL

    THIS IS THE GENERAL PURPOSE ADAPTIVE ARRAY PROGRAM EMUL.  EMUL IS
    CAPABLE OF SIMULATING A COMMUNICATION SYSTEM HAVING RECEIVING
    ELEMENTS IN SPACE EXCITED BY A SIMULATED SCENARIO.  THE SYSTEM IS
    SPECIFIED BY THE INTERCONNECTION OF STANDARD COMPONENT BUILDING
    BLOCKS INTERCONNECTED AT NODES.

    SYSTEM AND TEST RUN PARAMETERS ARE SPECIFIED BY THE USER IN AN
    INTERACTIVE DIALOG AND WRITTEN TO FILES.  THESE FILES ARE THEN USED
    TO SPECIFY SYSTEM CONFIGURATION AND TESTING MODE AT RUN TIME.

    THERE ARE THREE TYPES OF ANSWERS TO QUESTIONS USED IN THE
    INTERACTIVE PROGRAM CONSISTING OF YES AND NO, MENU SELECT, AND
    PARAMETER SPECIFICATION.  ALL USER COMMANDS MUST BE TERMINATED BY A
    CARRIAGE RETURN ('<CR>').

    THERE ARE SEVERAL COMMANDS THAT WILL BE VALID AT ANY TIME THAT A
    RESPONSE FROM YOU, THE USER, IS REQUIRED.  THESE COMMANDS CONSIST
    OF THE FOLLOWING:
         HELP-ADDITIONAL DETAILS ARE REQUESTED FOR QUESTION.
         EXIT-EXIT AFTER CLOSING FILES PRESENTLY BEING WRITTEN.
         BREAK-CLOSE FILES AND RETURN TO OPERATION SELECTION.

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         D   EXIT FROM EMUL
C

    WHAT IS THE NAME OF THE EXPERIMENT   SPECIFICATION FILE
    TO BE OPENED FOR WRITING?
FEDBAK.TSF

    At this time EMUL requires a general knowledge of the system that
    will now be tested.  How many input snapshots of the input data do
    you want to process?
3
```

```
    What are the total number of chips in the system you are
    specifying, that are not located within a cell?
1

    What are the total number of cells in the array processor?
0

    The following parameters have been specified for this system.  Do you wish t
o change anything?(yes or no)
          Number of snapshots:     3
          Number of chips:     1
          Number of cells:     0
NO

    For each input node of snap no.  1enter a line
    of input containing input node number, input data
    value and chip to which this data enters.

    How many input nodes will you enter at this time?
2

    ENTER   2 LINES OF INPUT DATA AT THIS TIME
    (input node no.,data value,input chip no.)
1 1 1
2 0 1

    For each input node of snap no.  2enter a line
    of input containing input node number, input data
    value and chip to which this data enters.

    How many input nodes will you enter at this time?
1

    ENTER   1 LINES OF INPUT DATA AT THIS TIME
    (input node no.,data value,input chip no.)
1 2 1

    For each input node of snap no.  3enter a line
    of input containing input node number, input data
    value and chip to which this data enters.

    How many input nodes will you enter at this time?
1

    ENTER   1 LINES OF INPUT DATA AT THIS TIME
    (input node no.,data value,input chip no.)
1 3 1

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         D   EXIT FROM EMUL
D
$ TYPE FEDBAK.TSF
XPERIMENT
  3
  1
  0
```

```
    1      1      1
    2      0      1
    1      2      1
    1      3      1
    1      0      0
$ RUN EMUL

    THIS IS THE GENERAL PURPOSE ADAPTIVE ARRAY PROGRAM EMUL.  EMUL IS
    CAPABLE OF SIMULATING A COMMUNICATION SYSTEM HAVING RECEIVING
    ELEMENTS IN SPACE EXCITED BY A SIMULATED SCENARIO.  HE SYSTEM IS
    SPECIFIED BY THE INTERCONNECTION OF STANDARD COMPONENT BUILDING
    BLOCKS INTERCONNECTED AT NODES.

    SYSTEM AND TEST RUN PARAMETERS ARE SPECIFIED BY THE USER IN AN
    INTERACTIVE DIALOG AND WRITTEN TO FILES.  THESE FILES ARE THEN USED
    TO SPECIFY SYSTEM CONFIGURATION AND TESTING MODE AT RUN TIME.

    THERE ARE THREE TYPES OF ANSWERS TO QUESTIONS USED IN THE
    INTERACTIVE PROGRAM CONSISTING OF YES AND NO, MENU SELECT, AND
    PARAMETER SPECIFICATION.  ALL USER COMMANDS MUST BE TERMINATED BY A
    CARRIAGE RETURN ('<CR>').

    THERE ARE SEVERAL COMMANDS THAT WILL BE VALID AT ANY TIME THAT A
    RESPONSE FROM YOU, THE USER, IS REQUIRED.  THESE COMMANDS CONSIST
    OF THE FOLLOWING:
         HELP-ADDITIONAL DETAILS ARE REQUESTED FOR QUESTION.
         EXIT-EXIT AFTER CLOSING FILES PRESENTLY BEING WRITTEN.
         BREAK-CLOSE FILES AND RETURN TO OPERATION SELECTION.

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         D   EXIT FROM EMUL
A
WHAT IS THE NAME OF THE INPUT EMU FILE?
FEDBAK.TSF
WHAT IS THE NAME OF THE OUTPUT FILE?
FEDBAK.OUT
WHAT IS THE NAME OF THE INPUT CHIP FILE?
FEDBAK.SSF
WHAT IS THE SPECIAL VISIBLE CHIP INPUT FILE
(ENTER 'NONE' IF THERE IS NONE)
(THE SPECIAL VISIBLE OUTPUT IS ALWAYS WRITTEN TO FILE 'SPVIS.OUT') ?
NONE
PULSING THE DATA...

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         D   EXIT FROM EMUL
D
$ TYPE FEDBAK.OUT
              *******THE SYSTOLIC EMULATOR HAS BEEN ACTIVATED*******

THE FOLLOWING INFORMATION REGARDING EACH ELEMENT HAS BEEN GIVEN TO THE EMULATOR

   CHIP NUMBER    INPUT NODES    OUTPUT NODE    CHIP OPERATION    CHIP CLOCK CYCLES
                    NUMBERS        NUMBER
```

```
        1         1    2          2           Addition              1


                  ***SNAPSHOT NUMBER  1  HAS BEGUN***
The fol lowing data has been accepted by the emulator for input as follows:
    Input Node Number       Actual Data Value
            1                   1.00
            2                   0.00


    ELEMENTS HAVE BEEN GROUPED ACCORDING TO INPUT READINESS.
  PROCESSING ACCORDING TO SPECIFIED OPERATION CAN NOW BEGIN!


    SNAPSHOT   1SHALL NOW BEGIN
////////////////////////////////////////////////////////////


    Cycle   1 of snapshot  1 is ready to process
         1 elements will output data.
       These Chips are:
            1. Chip Number    1
                  1.00    +  0.000E+00=   1.00
              OUTPUT OF CHIP    1  IS   1.00

////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////


                  ***SNAPSHOT NUMBER  2  HAS BEGUN***
The fol lowing data has been accepted by the emulator for input as follows:
    Input Node Number       Actual Data Value
            1                   2.00


    SNAPSHOT   2SHALL NOW BEGIN
////////////////////////////////////////////////////////////


    Cycle   1 of snapshot  2 is ready to process
         1 elements will output data.
       These Chips are:
            1. Chip Number    1
                  2.00    +   1.00    =   3.00
              OUTPUT OF CHIP    1  IS   3.00

////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////


                  ***SNAPSHOT NUMBER  3  HAS BEGUN***
The fol lowing data has been accepted by the emulator for input as follows:
    Input Node Number       Actual Data Value
```

```
           1                    3.00


    SNAPSHOT   3SHALL NOW BEGIN
////////////////////////////////////////////////////////////


    Cycle   1 of snapshot  3 is ready to process
          1 elements will output data.
       These Chips are:
            1. Chip Number    1
                  3.00    +   3.00    =   6.00
              OUTPUT OF CHIP    1  IS   6.00

////////////////////////////////////////////////////////////
////////////////////////////////////////////////////////////


    ALL AVAILABLE INPUT DATA HAS BEEN READ.
                   THE EMULATOR WILL NOW BE DEACTIVATED
$ LOG
  SMITHR       logged out at 15-DEC-1989 11:03:41.29Connection closed by remote
```

Appendix D

Associated SMI Processor Emulation Files

```
        Welcome to VAX/VMS V5.2

Username: SMITHR
Password:
        Welcome to VAX/VMS version V5.2 on node MISVX1
    Last interactive login on Thursday, 21-DEC-1989 14:06Z>
●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●
 Lookup the phone number and office symbol of RADC personel, use the
 FIND command.
-------------------------------------------------------------------------------
 Send your MISVAX files to a LONEX printer, use the LP command.
-------------------------------------------------------------------------------
 To get information on special utilities installed on the 8650 cluster,
 type 'help @RADC' at the $ prompt.
/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/>
$ dir

Directory DC$DISK2:[SMITHR]

ALGOR1.SSF;1          ALGOR1.TSF;1          BOTH.DIR;1            EMUL.DIR;1
GADAR.DIR;1           INFO.DIR;1            LOGIN.COM;4           LOGIN.COM;3
LOGIN.COM;2           LOGIN.JOU;1           SYSTEM.DIR;1

Total of 11 files.
$ type algor1.tsf
EXPERIMENT
  8
 47
  9
    1      2      1
    2      0      2
    3      1      3
    4      0      4
    5      2      5
    6     -1      6
    7     -1      7
    1      1      1
    2      0      2
    3      2      3
    4      0      4
    5      1      5
    6     -2      6
    7     -1      7
    1      1      1
    2     -1      2
    3      1      3
    4      2      4
    5      3      5
    6     -2      6
    7     -1      7
    1      2      1
    2      3      2
    3     -1      3
    4     -1      4
    5      1      5
    6      4      6
    7     -1      7
    1      2      1
```

```
    2      0      2
    3      1      3
    4      0      4
    5      3      5
    6      1      6
    7     -1      7
    1      0      1
    2     -1      2
    3      2      3
    4      0      4
    5      3      5
    6     -3      6
    7     -1      7
    1      1      1
    2     -1      2
    3      1      3
    4      2      4
    5      5      5
    6      1      6
    7     -1      7
    1      2      1
    2      3      2
    3     -1      3
    4     -1      4
    5     -3      5
    6      5      6
    7     -1      7
    1      0      0
$ dir

Directory DCSDISK2:[SMITHR]

ALGOR1.SSF;1          ALGOR1.TSF;1          BOTH.DIR;1            EMUL.DIR;1
GADAR.DIR;1           INFO.DIR;1            LOGIN.COM;4           LOGIN.COM;3
LOGIN.COM;2           LOGIN.JOU;1           SYSTEM.DIR;1

Total of 11 files.
$ type algor1.ssf
CONFIGURATIN
    1     0  101   FLOT   DELY    32     0
    2     0  102   FLOT   DELY    32     0
    3     0  401   FLOT   DELY    32     0
    4     0  402   FLOT   DELY    32     0
    5     0  603   FLOT   DELY    32     0
    6     0  604   FLOT   DELY    32     0
    7     0  605   FLOT   DELY    32     0
  101     0  201   FLOT   DELY    32     0
  401     0  301   FLOT   DELY    32     0
  102     0  202   FLOT   DELY    32     0
  402     0  204   FLOT   DELY    32     0
  402     0  302   FLOT   DELY    32     0
  401     0  203   FLOT   DELY    32     0
  603     0  503   FLOT   DELY    32     0
  401     0  601   FLOT   DELY    32     0
  101     0  303   FLOT   DELY    32     0
  101     0  501   FLOT   DELY    32     0
  604     0  504   FLOT   DELY    32     0
  102     0  304   FLOT   DELY    32     0
  102     0  502   FLOT   DELY    32     0
  402     0  602   FLOT   DELY    32     0
```

```
605     0   205   FLOT   DELY    32     0
605     0   305   FLOT   DELY    32     0
605     0   505   FLOT   DELY    32     0
115     0   701   FLOT   DELY    32     0
230     0   703   FLOT   DELY    32     0
231     0   704   FLOT   DELY    32     0
330     0   807   FLOT   DELY    32     0
331     0   808   FLOT   DELY    32     0
415     0   702   FLOT   DELY    32     0
530     0   805   FLOT   DELY    32     0
531     0   806   FLOT   DELY    32     0
630     0   905   FLOT   DELY    32     0
631     0   906   FLOT   DELY    32     0
605     0   909   FLOT   DELY    32     8
909     0   705   FLOT   DELY    32     0
701     0   802   FLOT   DELY    32     0
702     0   902   FLOT   DELY    32     0
805     0   903   FLOT   DELY    32     0
806     0   904   FLOT   DELY    32     0
703     0   907   FLOT   DELY    32     0
704     0   908   FLOT   DELY    32     0
905     0   803   FLOT   DELY    32     0
906     0   804   FLOT   DELY    32     0
909     0   809   FLOT   DELY    32     0
722     0   801   FLOT   DELY    32     0
722     0   901   FLOT   DELY    32     0
  2     1    13
  1     0     3   FLOT   DELY    32     1
  2     0     4   FLOT   DELY    32     1
  3     0     5   FLOT   DELY    32     0
  4     0     6   FLOT   DELY    32     0
  3     5     7   FLOT   MULT    32     1
  6     4     8   FLOT   MULT    32     1
  7     8     9   FLOT   ADDR    32     1
  9     0    10   FLOT   DELY    32     1
 10     0    11   FLOT   DELY    32     1
 10     9    12   FLOT   ADDR    32     1
 11     0    13   FLOT   DELY    32     1
 13    11    14   FLOT   ADDR    32     1
 14    12    15   FLOT   ADDR    32     1
  5     2    26
  1     0     6   FLOT   DELY    32     0
  2     0     7   FLOT   DELY    32     0
  3     0     8   FLOT   DELY    32     0
  4     0     9   FLOT   DELY    32     0
  5     0    10   FLOT   DELY    32     1
  6     8    11   FLOT   MULT    32     1
  7     9    12   FLOT   MULT    32     1
  8     7    13   FLOT   MULT    32     1
  9     6    14   FLOT   MULT    32     1
 11    12    15   FLOT   ADDR    32     1
 13    10    16   FLOT   MULT    32     1
 14     0    17   FLOT   DELY    32     1
 15     0    18   FLOT   DELY    32     1
 16    17    19   FLOT   ADDR    32     1
 18     0    20   FLOT   DELY    32     1
 19     0    21   FLOT   DELY    32     1
 20     0    22   FLOT   DELY    32     1
 20    18    23   FLOT   ADDR    32     1
 19    21    24   FLOT   ADDR    32     1
```

```
21    0   25   FLOT   DELY   32   1
22    0   26   FLOT   DELY   32   1
25    0   27   FLOT   DELY   32   1
26   22   28   FLOT   ADDR   32   1
25   27   29   FLOT   ADDR   32   1
28   23   30   FLOT   ADDR   32   1
24   29   31   FLOT   ADDR   32   1
 5    2   26
 1    0    6   FLOT   DELY   32   0
 2    0    7   FLOT   DELY   32   0
 3    0    8   FLOT   DELY   32   0
 4    0    9   FLOT   DELY   32   0
 5    0   10   FLOT   DELY   32   1
 6    8   11   FLOT   MULT   32   1
 7    9   12   FLOT   MULT   32   1
 8    7   13   FLOT   MULT   32   1
 9    6   14   FLOT   MULT   32   1
11   12   15   FLOT   ADDR   32   1
13   10   16   FLOT   MULT   32   1
14    0   17   FLOT   DELY   32   1
15    0   18   FLOT   DELY   32   1
16   17   19   FLOT   ADDR   32   1
18    0   20   FLOT   DELY   32   1
19    0   21   FLOT   DELY   32   1
20    0   22   FLOT   DELY   32   1
20   18   23   FLOT   ADDR   32   1
19   21   24   FLOT   ADDR   32   1
21    0   25   FLOT   DELY   32   1
22    0   26   FLOT   DELY   32   1
25    0   27   FLOT   DELY   32   1
26   22   28   FLOT   ADDR   32   1
25   27   29   FLOT   ADDR   32   1
28   23   30   FLOT   ADDR   32   1
24   29   31   FLOT   ADDR   32   1
 2    1   13
 1    0    3   FLOT   DELY   32   1
 2    0    4   FLOT   DELY   32   1
 3    0    5   FLOT   DELY   32   0
 4    0    6   FLOT   DELY   32   0
 3    5    7   FLOT   MULT   32   1
 6    4    8   FLOT   MULT   32   1
 7    8    9   FLOT   ADDR   32   1
 9    0   10   FLOT   DELY   32   1
10    0   11   FLOT   DELY   32   1
10    9   12   FLOT   ADDR   32   1
11    0   13   FLOT   DELY   32   1
13   11   14   FLOT   ADDR   32   1
14   12   15   FLOT   ADDR   32   1
 5    2   26
 1    0    6   FLOT   DELY   32   0
 2    0    7   FLOT   DELY   32   0
 3    0    8   FLOT   DELY   32   0
 4    0    9   FLOT   DELY   32   0
 5    0   10   FLOT   DELY   32   1
 6    8   11   FLOT   MULT   32   1
 7    9   12   FLOT   MULT   32   1
 8    7   13   FLOT   MULT   32   1
 9    6   14   FLOT   MULT   32   1
11   12   15   FLOT   ADDR   32   1
13   10   16   FLOT   MULT   32   1
```

```
14    0   17   FLOT   DELY    32    1
15    0   18   FLOT   DELY    32    1
16   17   19   FLOT   ADDR    32    1
18    0   20   FLOT   DELY    32    1
19    0   21   FLOT   DELY    32    1
20    0   22   FLOT   DELY    32    1
20   18   23   FLOT   ADDR    32    1
19   21   24   FLOT   ADDR    32    1
21    0   25   FLOT   DELY    32    1
22    0   26   FLOT   DELY    32    1
25    0   27   FLOT   DELY    32    1
26   22   28   FLOT   ADDR    32    1
25   27   29   FLOT   ADDR    32    1
28   23   30   FLOT   ADDR    32    1
24   29   31   FLOT   ADDR    32    1
 5    2   26
 1    0    6   FLOT   DELY    32    0
 2    0    7   FLOT   DELY    32    0
 3    0    8   FLOT   DELY    32    0
 4    0    9   FLOT   DELY    32    0
 5    0   10   FLOT   DELY    32    1
 6    8   11   FLOT   MULT    32    1
 7    9   12   FLOT   MULT    32    1
 8    7   13   FLOT   MULT    32    1
 9    6   14   FLOT   MULT    32    1
11   12   15   FLOT   ADDR    32    1
13   10   16   FLOT   MULT    32    1
14    0   17   FLOT   DELY    32    1
15    0   18   FLOT   DELY    32    1
16   17   19   FLOT   ADDR    32    1
18    0   20   FLOT   DELY    32    1
19    0   21   FLOT   DELY    32    1
20    0   22   FLOT   DELY    32    1
20   18   23   FLOT   ADDR    32    1
19   21   24   FLOT   ADDR    32    1
21    0   25   FLOT   DELY    32    1
22    0   26   FLOT   DELY    32    1
25    0   27   FLOT   DELY    32    1
26   22   28   FLOT   ADDR    32    1
25   27   29   FLOT   ADDR    32    1
28   23   30   FLOT   ADDR    32    1
24   29   31   FLOT   ADDR    32    1
5    1   17
 1    0    6   FLOT   DELY    32    0
 2    0    7   FLOT   DELY    32    0
 3    0    8   FLOT   DELY    32    1
 4    0    9   FLOT   DELY    32    1
 5    0   10   FLOT   DELY    32    3
 6    7   11   FLOT   MULT    32    1
11    0   12   FLOT   DELY    32    3
 8    0   13   FLOT   DELY    32    0
 9    0   14   FLOT   DELY    32    0
 8   13   15   FLOT   MULT    32    1
 9   14   16   FLOT   MULT    32    1
15   16   17   FLOT   ADDR    32    1
17   10   18   FLOT   MULT    32    1
12   18   19   FLOT   ADDR    32    1
19    0   20   FLOT   DELY    32    0
19   20   21   FLOT   MULT    32    1
21    0   22   FLOT   LOOK    32    1
```

```
9     2     32
 1     0     10   FLOT    DELY     32     0
 2     0     11   FLOT    DELY     32     0
 3     0     12   FLOT    DELY     32     0
 4     0     13   FLOT    DELY     32     0
 5     0     14   FLOT    DELY     32     0
 6     0     15   FLOT    DELY     32     0
 7     0     16   FLOT    DELY     32     0
 8     0     17   FLOT    DELY     32     0
 9     0     18   FLOT    DELY     32     1
12    11     19   FLOT    MULT     32     1
13    11     20   FLOT    MULT     32     1
14    16     21   FLOT    MULT     32     1
15    17     22   FLOT    MULT     32     1
16    15     23   FLOT    MULT     32     1
17    14     24   FLOT    MULT     32     1
18     0     25   FLOT    DELY     32     2
19     0     26   FLOT    DELY     32     3
20     0     27   FLOT    DELY     32     3
21     0     28   FLOT    DELY     32     1
22    18     29   FLOT    MULT     32     1
23     0     30   FLOT    DELY     32     1
24     0     31   FLOT    DELY     32     1
28    29     32   FLOT    ADDR     32     1
30    31     33   FLOT    ADDR     32     1
32    25     34   FLOT    MULT     32     1
25    33     35   FLOT    MULT     32     1
26    34     36   FLOT    ADDR     32     1
27    35     37   FLOT    ADDR     32     1
36     0     38   FLOT    DELY     32     2
37     0     39   FLOT    DELY     32     2
10    38     40   FLOT    MULT     32     1
10    39     41   FLOT    MULT     32     1
9     2      32
 1     0     10   FLOT    DELY     32     0
 2     0     11   FLOT    DELY     32     0
 3     0     12   FLOT    DELY     32     0
 4     0     13   FLOT    DELY     32     0
 5     0     14   FLOT    DELY     32     0
 6     0     15   FLOT    DELY     32     0
 7     0     16   FLOT    DELY     32     0
 8     0     17   FLOT    DELY     32     0
 9     0     18   FLOT    DELY     32     1
12    11     19   FLOT    MULT     32     1
13    11     20   FLOT    MULT     32     1
14    16     21   FLOT    MULT     32     1
15    17     22   FLOT    MULT     32     1
16    15     23   FLOT    MULT     32     1
17    14     24   FLOT    MULT     32     1
18     0     25   FLOT    DELY     32     2
19     0     26   FLOT    DELY     32     3
20     0     27   FLOT    DELY     32     3
21     0     28   FLOT    DELY     32     1
22    18     29   FLOT    MULT     32     1
23     0     30   FLOT    DELY     32     1
24     0     31   FLOT    DELY     32     1
28    29     32   FLOT    ADDR     32     1
30    31     33   FLOT    ADDR     32     1
32    25     34   FLOT    MULT     32     1
25    33     35   FLOT    MULT     32     1
```

```
   26    34    36    FLOT    ADDR     32     1
   27    35    37    FLOT    ADDR     32     1
   36     0    38    FLOT    DELY     32     2
   37     0    39    FLOT    DELY     32     2
   10    38    40    FLOT    MULT     32     1
   10    39    41    FLOT    MULT     32     1
$ log
  SMITHR       logged out at 21-DEC-1989 14:10:57.49Connection closed by remote ho
```

```
        Welcome to VAX/VMS V5.2

Username: SMITHR
Password:
        Welcome to VAX/VMS version V5.2 on node MISVX1
    Last interactive login on Friday, 22-DEC-1989 07:51Z>
●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●
 Lookup the phone number and office symbol of RADC personel, use the
 FIND command.
--------------------------------------------------------------------------------
 Send your MISVAX files to a LONEX printer, use the LP command.
--------------------------------------------------------------------------------
 To get information on special utilities installed on the 8650 cluster,
 type 'help @RADC' at the $ prompt.
/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/●/>
$ SET DEF [SMITHR.EMUL]
$ DIR

Directory DC$DISK2:[SMITHR.EMUL]

ALGOR1.CUT;1        ALGOR1.SSF;1        ALGOR1.TSF;1        BACSUB.SSF;1
BACSUB.TSF;1        BNDCEL.SSF;1        BNDCEL.TSF;1        BNDCL2.SSF;1
BNDCL2.TSF;1        CACEL.SSF;1         CBACSB.SSF;1        CBNDC2.SSF;1
CBNDCL.SSF;1        CBNDCL.TSF;1        CCMCEL.SSF;1        CCOREL.SSF;1
CCOREL.TSF;1        CINTC2.SSF;1        CINTCL.SSF;1        CMCEL.SSF;1
CMULCL.SSF;1        CMULCL.TSF;1        CMXSOL.3SF;1        CMXSOL.TSF;1
COM.DIR;1           CORREL.SSF;1        CSMCEL.SSF;1        CSMI.SSF;1
CSMI.TSF;1          CVDCEL.SSF;1        CVMCEL.SSF;1        EMUL.EXE;1
EXPCEL.SSF;1        EXPCEL.TSF;1        FEDBAK.SSF;1        FEDBAK.TSF;1
GIV2.SSF;1          GIV2.TSF;1          GIV3.SSF;1          GIV3.TSF;1
GIV4.SSF;1          IDTCEL.SSF;1        IDTCEL.TSF;1        INTCEL.SSF;1
INTCEL.TSF;1        MATSOL.SSF;1        MUX.SSF;3           MUX.SSF;2
MUX.SSF;1           MUX.TSF;8           MUX.TSF;7           MUX.TSF;6
MUX.TSF;5           MUX.TSF;4           MUX.TSF;3           MUX.TSF;2
MUX.TSF;1           SMI.SSF;1           SOURCE.DIR;1        TEST.DIR;1
TYPE.;1             WTCEL.SSF;1         WTCEL.TSF;1

Total of 63 files.
$ RUN EMUL
```

THIS IS THE GENERAL PURPOSE ADAPTIVE ARRAY PROGRAM EMUL. EMUL IS CAPABLE OF SIMULATING A COMMUNICATION SYSTEM HAVING RECEIVING ELEMENTS IN SPACE EXCITED BY A SIMULATED SCENARIO. THE SYSTEM IS SPECIFIED BY THE INTERCONNECTION OF STANDARD COMPONENT BUILDING BLOCKS INTERCONNECTED AT NODES.

SYSTEM AND TEST RUN PARAMETERS ARE SPECIFIED BY THE USER IN AN INTERACTIVE DIALOG AND WRITTEN TO FILES. THESE FILES ARE THEN USED TO SPECIFY SYSTEM CONFIGURATION AND TESTING MODE AT RUN TIME.

THERE ARE THREE TYPES OF ANSWERS TO QUESTIONS USED IN THE INTERACTIVE PROGRAM CONSISTING OF YES AND NO, MENU SELECT, AND PARAMETER SPECIFICATION. ALL USER COMMANDS MUST BE TERMINATED BY A CARRIAGE RETURN ('<CR>').

THERE ARE SEVERAL COMMANDS THAT WILL BE VALID AT ANY TIME THAT A RESPONSE FROM YOU, THE USER, IS REQUIRED. THESE COMMANDS CONSIST OF THE FOLLOWING:

```
        HELP-ADDITIONAL DETAILS ARE REQUESTED FOR QUESTION.
        EXIT-EXIT AFTER CLOSING FILES PRESENTLY BEING WRITTEN.
        BREAK-CLOSE FILES AND RETURN TO OPERATION SELECTION.

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         D   EXIT FROM EMUL
A
WHAT IS THE NAME OF THE INPUT EMU FILE?
ALGOR1.TSF
WHAT IS THE NAME OF THE OUTPUT FILE?
ALGOR1.OUT
WHAT IS THE NAME OF THE INPUT CHIP FILE?
ALGOR1.SSF
WHAT IS THE SPECIAL VISIBLE CHIP INPUT FILE
(ENTER 'NONE' IF THERE IS NONE)
(THE SPECIAL VISIBLE OUTPUT IS ALWAYS WRITTEN TO FILE 'SPVIS.OUT') ?
NONE
PULSING THE DATA...

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         D   EXIT FROM EMUL
D
$ TYPE ALGOR1.OUT
              *******THE SYSTOLIC EMULATOR HAS BEEN ACTIVATED*******

THE FOLLOWING INFORMATION REGARDING EACH ELEMENT HAS BEEN GIVEN TO THE EMULATOR
```

CHIP NUMBER	INPUT NODES NUMBERS		OUTPUT NODE NUMBER	CHIP OPERATION	CHIP CLOCK CYCLES
1	1	0	101	Delay (Time Shift)	0
2	2	0	102	Delay (Time Shift)	0
3	3	0	401	Delay (Time Shift)	0
4	4	0	402	Delay (Time Shift)	0
5	5	0	603	Delay (Time Shift)	0
6	6	0	604	Delay (Time Shift)	0
7	7	0	605	Delay (Time Shift)	0
8	101	0	201	Delay (Time Shift)	0
9	401	0	301	Delay (Time Shift)	0
10	102	0	202	Delay (Time Shift)	0
11	402	0	204	Delay (Time Shift)	0
12	402	0	302	Delay (Time Shift)	0
13	401	0	203	Delay (Time Shift)	0
14	603	0	503	Delay (Time Shift)	0
15	401	0	601	Delay (Time Shift)	0
16	101	0	303	Delay (Time Shift)	0
17	101	0	501	Delay (Time Shift)	0
18	604	0	504	Delay (Time Shift)	0
19	102	0	304	Delay (Time Shift)	0
20	102	0	502	Delay (Time Shift)	0
21	402	0	602	Delay (Time Shift)	0
22	605	0	205	Delay (Time Shift)	0
23	605	0	305	Delay (Time Shift)	0
24	605	0	505	Delay (Time Shift)	0

25	115	0	701	Delay (Time Shift)	0
26	230	0	703	Delay (Time Shift)	0
27	231	0	704	Delay (Time Shift)	0
28	330	0	807	Delay (Time Shift)	0
29	331	0	808	Delay (Time Shift)	0
30	415	0	702	Delay (Time Shift)	0
31	530	0	805	Delay (Time Shift)	0
32	531	0	806	Delay (Time Shift)	0
33	630	0	905	Delay (Time Shift)	0
34	631	0	906	Delay (Time Shift)	0
35	605	0	909	Delay (Time Shift)	8
36	909	0	705	Delay (Time Shift)	0
37	701	0	802	Delay (Time Shift)	0
38	702	0	902	Delay (Time Shift)	0
39	805	0	903	Delay (Time Shift)	0
40	806	0	904	Delay (Time Shift)	0
41	703	0	907	Delay (Time Shift)	0
42	704	0	908	Delay (Time Shift)	0
43	905	0	803	Delay (Time Shift)	0
44	906	0	804	Delay (Time Shift)	0
45	909	0	809	Delay (Time Shift)	0
46	722	0	801	Delay (Time Shift)	0
47	722	0	901	Delay (Time Shift)	0

SNAPSHOT NUMBER 1 HAS BEGUN

The fol lowing data has been accepted by the emulator for input as follows:

Input Node Number	Actual Data Value
1	2.00
2	0.00
3	1.00
4	0.00
5	2.00
6	-1.00
7	-1.00

101	1	0	3	Delay (Time Shift)	1
102	2	0	4	Delay (Time Shift)	1
103	3	0	5	Delay (Time Shift)	0
104	4	0	6	Delay (Time Shift)	0
105	3	5	7	Delay (Time Shift)	1
106	6	4	8	Delay (Time Shift)	1
107	7	8	9	Delay (Time Shift)	1
108	9	0	10	Delay (Time Shift)	1
109	10	0	11	Delay (Time Shift)	1
110	10	9	12	Delay (Time Shift)	1
111	11	0	13	Delay (Time Shift)	1
112	13	11	14	Delay (Time Shift)	1
113	14	12	15	Delay (Time Shift)	1
201	1	0	6	Delay (Time Shift)	0
202	2	0	7	Delay (Time Shift)	0
203	3	0	8	Delay (Time Shift)	0
204	4	0	9	Delay (Time Shift)	0
205	5	0	10	Delay (Time Shift)	1
206	6	8	11	Delay (Time Shift)	1
207	7	9	12	Delay (Time Shift)	1
208	8	7	13	Delay (Time Shift)	1
209	9	6	14	Delay (Time Shift)	1
210	11	12	15	Delay (Time Shift)	1
211	13	10	16	Delay (Time Shift)	1

212	14	0	17	Delay (Time Shift)	1
213	15	0	18	Delay (Time Shift)	1
214	16	17	19	Delay (Time Shift)	1
215	18	0	20	Delay (Time Shift)	1
216	19	0	21	Delay (Time Shift)	1
217	20	0	22	Delay (Time Shift)	1
218	20	18	23	Delay (Time Shift)	1
219	19	21	24	Delay (Time Shift)	1
220	21	0	25	Delay (Time Shift)	1
221	22	0	26	Delay (Time Shift)	1
222	25	0	27	Delay (Time Shift)	1
223	26	22	28	Delay (Time Shift)	1
224	25	27	29	Delay (Time Shift)	1
225	28	23	30	Delay (Time Shift)	1
226	24	29	31	Delay (Time Shift)	1
301	1	0	6	Delay (Time Shift)	0
302	2	0	7	Delay (Time Shift)	0
303	3	0	8	Delay (Time Shift)	0
304	4	0	9	Delay (Time Shift)	0
305	5	0	10	Delay (Time Shift)	1
306	6	8	11	Delay (Time Shift)	1
307	7	9	12	Delay (Time Shift)	1
308	8	7	13	Delay (Time Shift)	1
309	9	6	14	Delay (Time Shift)	1
310	11	12	15	Delay (Time Shift)	1
311	13	10	16	Delay (Time Shift)	1
312	14	0	17	Delay (Time Shift)	1
313	15	0	18	Delay (Time Shift)	1
314	16	17	19	Delay (Time Shift)	1
315	18	0	20	Delay (Time Shift)	1
316	19	0	21	Delay (Time Shift)	1
317	20	0	22	Delay (Time Shift)	1
318	20	18	23	Delay (Time Shift)	1
319	19	21	24	Delay (Time Shift)	1
320	21	0	25	Delay (Time Shift)	1
321	22	0	26	Delay (Time Shift)	1
322	25	0	27	Delay (Time Shift)	1
323	26	22	28	Delay (Time Shift)	1
324	25	27	29	Delay (Time Shift)	1
325	28	23	30	Delay (Time Shift)	1
326	24	29	31	Delay (Time Shift)	1
401	1	0	3	Delay (Time Shift)	1
402	2	0	4	Delay (Time Shift)	1
403	3	0	5	Delay (Time Shift)	0
404	4	0	6	Delay (Time Shift)	0
405	3	5	7	Delay (Time Shift)	1
406	6	4	8	Delay (Time Shift)	1
407	7	8	9	Delay (Time Shift)	1
408	9	0	10	Delay (Time Shift)	1
409	10	0	11	Delay (Time Shift)	1
410	10	9	12	Delay (Time Shift)	1
411	11	0	13	Delay (Time Shift)	1
412	13	11	14	Delay (Time Shift)	1
413	14	12	15	Delay (Time Shift)	1
501	1	0	6	Delay (Time Shift)	0
502	2	0	7	Delay (Time Shift)	0
503	3	0	8	Delay (Time Shift)	0
504	4	0	9	Delay (Time Shift)	0
505	5	0	10	Delay (Time Shift)	1
506	6	8	11	Delay (Time Shift)	1

507	7	9	12	Delay (Time Shift)	1
508	8	7	13	Delay (Time Shift)	1
509	9	6	14	Delay (Time Shift)	1
510	11	12	15	Delay (Time Shift)	1
511	13	10	16	Delay (Time Shift)	1
512	14	0	17	Delay (Time Shift)	1
513	15	0	18	Delay (Time Shift)	1
514	16	17	19	Delay (Time Shift)	1
515	18	0	20	Delay (Time Shift)	1
516	19	0	21	Delay (Time Shift)	1
517	20	0	22	Delay (Time Shift)	1
518	20	18	23	Delay (Time Shift)	1
519	19	21	24	Delay (Time Shift)	1
520	21	0	25	Delay (Time Shift)	1
521	22	0	26	Delay (Time Shift)	1
522	25	0	27	Delay (Time Shift)	1
523	26	22	28	Delay (Time Shift)	1
524	25	27	29	Delay (Time Shift)	1
525	28	23	30	Delay (Time Shift)	1
526	24	29	31	Delay (Time Shift)	1
601	1	0	6	Delay (Time Shift)	0
602	2	0	7	Delay (Time Shift)	0
603	3	0	8	Delay (Time Shift)	0
604	4	0	9	Delay (Time Shift)	0
605	5	0	10	Delay (Time Shift)	1
606	6	8	11	Delay (Time Shift)	1
607	7	9	12	Delay (Time Shift)	1
608	8	7	13	Delay (Time Shift)	1
609	9	6	14	Delay (Time Shift)	1
610	11	12	15	Delay (Time Shift)	1
611	13	10	16	Delay (Time Shift)	1
612	14	0	17	Delay (Time Shift)	1
613	15	0	18	Delay (Time Shift)	1
614	16	17	19	Delay (Time Shift)	1
615	18	0	20	Delay (Time Shift)	1
616	19	0	21	Delay (Time Shift)	1
617	20	0	22	Delay (Time Shift)	1
618	20	18	23	Delay (Time Shift)	1
619	19	21	24	Delay (Time Shift)	1
620	21	0	25	Delay (Time Shift)	1
621	22	0	26	Delay (Time Shift)	1
622	25	0	27	Delay (Time Shift)	1
623	26	22	28	Delay (Time Shift)	1
624	25	27	29	Delay (Time Shift)	1
625	28	23	30	Delay (Time Shift)	1
626	24	29	31	Delay (Time Shift)	1
701	1	0	6	Delay (Time Shift)	0
702	2	0	7	Delay (Time Shift)	0
703	3	0	8	Delay (Time Shift)	1
704	4	0	9	Delay (Time Shift)	1
705	5	0	10	Delay (Time Shift)	3
706	6	7	11	Delay (Time Shift)	1
707	11	0	12	Delay (Time Shift)	3
708	8	0	13	Delay (Time Shift)	0
709	9	0	14	Delay (Time Shift)	0
710	8	13	15	Delay (Time Shift)	1
711	9	14	16	Delay (Time Shift)	1
712	15	16	17	Delay (Time Shift)	1
713	17	10	18	Delay (Time Shift)	1
714	12	18	19	Delay (Time Shift)	1

715	19	0	20	Delay (Time Shift)	0
716	19	20	21	Delay (Time Shift)	1
717	21	0	22	Delay (Time Shift)	1
801	1	0	10	Delay (Time Shift)	0
802	2	0	11	Delay (Time Shift)	0
803	3	0	12	Delay (Time Shift)	0
804	4	0	13	Delay (Time Shift)	0
805	5	0	14	Delay (Time Shift)	0
806	6	0	15	Delay (Time Shift)	0
807	7	0	16	Delay (Time Shift)	0
808	8	0	17	Delay (Time Shift)	0
809	9	0	18	Delay (Time Shift)	1
810	12	11	19	Delay (Time Shift)	1
811	13	11	20	Delay (Time Shift)	1
812	14	16	21	Delay (Time Shift)	1
813	15	17	22	Delay (Time Shift)	1
814	16	15	23	Delay (Time Shift)	1
815	17	14	24	Delay (Time Shift)	1
816	18	0	25	Delay (Time Shift)	2
817	19	0	26	Delay (Time Shift)	3
818	20	0	27	Delay (Time Shift)	3
819	21	0	28	Delay (Time Shift)	1
820	22	18	29	Delay (Time Shift)	1
821	23	0	30	Delay (Time Shift)	1
822	24	0	31	Delay (Time Shift)	1
823	28	29	32	Delay (Time Shift)	1
824	30	31	33	Delay (Time Shift)	1
825	32	25	34	Delay (Time Shift)	1
826	25	33	35	Delay (Time Shift)	1
827	26	34	36	Delay (Time Shift)	1
828	27	35	37	Delay (Time Shift)	1
829	36	0	38	Delay (Time Shift)	2
830	37	0	39	Delay (Time Shift)	2
831	10	38	40	Delay (Time Shift)	1
832	10	39	41	Delay (Time Shift)	1
901	1	0	10	Delay (Time Shift)	0
902	2	0	11	Delay (Time Shift)	0
903	3	0	12	Delay (Time Shift)	0
904	4	0	13	Delay (Time Shift)	0
905	5	0	14	Delay (Time Shift)	0
906	6	0	15	Delay (Time Shift)	0
907	7	0	16	Delay (Time Shift)	0
908	8	0	17	Delay (Time Shift)	0
909	9	0	18	Delay (Time Shift)	1
910	12	11	19	Delay (Time Shift)	1
911	13	11	20	Delay (Time Shift)	1
912	14	16	21	Delay (Time Shift)	1
913	15	17	22	Delay (Time Shift)	1
914	16	15	23	Delay (Time Shift)	1
915	17	14	24	Delay (Time Shift)	1
916	18	0	25	Delay (Time Shift)	2
917	19	0	26	Delay (Time Shift)	3
918	20	0	27	Delay (Time Shift)	3
919	21	0	28	Delay (Time Shift)	1
920	22	18	29	Delay (Time Shift)	1
921	23	0	30	Delay (Time Shift)	1
922	24	0	31	Delay (Time Shift)	1
923	28	29	32	Delay (Time Shift)	1
924	30	31	33	Delay (Time Shift)	1
925	32	25	34	Delay (Time Shift)	1

```
926        25   33        35          Delay (Time Shift)   1
927        26   34        36          Delay (Time Shift)   1
928        27   35        37          Delay (Time Shift)   1
929        36    0        38          Delay (Time Shift)   2
930        37    0        39          Delay (Time Shift)   2
931        10   38        40          Delay (Time Shift)   1
932        10   39        41          Delay (Time Shift)   1


   ELEMENTS HAVE BEEN GROUPED ACCORDING TO INPUT READINESS.
PROCESSING ACCORDING TO SPECIFIED OPERATION CAN NOW BEGIN!


                  ***SNAPSHOT NUMBER  8  HAS BEGUN***
The fol lowing data has been accepted by the emulator for input as follows:
    Input Node Number       Actual Data Value
           1                      2.00
           2                      3.00
           3                     -1.00
           4                     -1.00
           5                     -3.00
           6                      5.00
           7                     -1.00


   SNAPSHOT   8SHALL NOW BEGIN
////////////////////////////////////////////////////////////


    Cycle   8 of snapshot  1 is ready to process
         11 elements will output data.
       These Chips are:
            1. Chip Number   35
               OUTPUT OF DELAY CHIP   35  IS  -1.00
               IT HAS A DELAYOF   8  CLOCK CYCLES
               OUTPUT OF CHIP   35  IS  -1.00

            2. Chip Number  113
               OUTPUT OF DELAY CHIP  113  IS   2.00
               IT HAS A DELAYOF   1  CLOCK CYCLES
               OUTPUT OF CHIP  113  IS   2.00

            3. Chip Number  413
               OUTPUT OF DELAY CHIP  413  IS   1.00
               IT HAS A DELAYOF   1  CLOCK CYCLES
               OUTPUT OF CHIP  413  IS   1.00

            4. Chip Number  225
               OUTPUT OF DELAY CHIP  225  IS   2.00
               IT HAS A DELAYOF   1  CLOCK CYCLES
               OUTPUT OF CHIP  225  IS   2.00

            5. Chip Number  226
               OUTPUT OF DELAY CHIP  226  IS  -1.00
               IT HAS A DELAYOF   1  CLOCK CYCLES
               OUTPUT OF CHIP  226  IS  -1.00

            6. Chip Number  325
```

```
          OUTPUT OF DELAY CHIP  325  IS   1.00
          IT HAS A DELAYOF   1  CLOCK CYCLES
          OUTPUT OF CHIP  325  IS   1.00

       7. Chip Number  326
          OUTPUT OF DELAY CHIP  326  IS   2.00
          IT HAS A DELAYOF   1  CLOCK CYCLES
          OUTPUT OF CHIP  326  IS   2.00

       8. Chip Number  525
          OUTPUT OF DELAY CHIP  525  IS   2.00
          IT HAS A DELAYOF   1  CLOCK CYCLES
          OUTPUT OF CHIP  525  IS   2.00

       9. Chip Number  526
          OUTPUT OF DELAY CHIP  526  IS   1.00
          IT HAS A DELAYOF   1  CLOCK CYCLES
          OUTPUT OF CHIP  526  IS   1.00

      10. Chip Number  625
          OUTPUT OF DELAY CHIP  625  IS   1.00
          IT HAS A DELAYOF   1  CLOCK CYCLES
          OUTPUT OF CHIP  625  IS   1.00

      11. Chip Number  626
          OUTPUT OF DELAY CHIP  626  IS   1.00
          IT HAS A DELAYOF   1  CLOCK CYCLES
          OUTPUT OF CHIP  626  IS   1.00

////////////////////////////////////////////////////////////

Cycle  16 of snapshot  1 is ready to process
     8 elements will output data.
  These Chips are:
       1. Chip Number   46
          OUTPUT OF DELAY CHIP   46  IS   2.00
          IT HAS A DELAYOF   0  CLOCK CYCLES
          OUTPUT OF CHIP   46  IS   2.00

       2. Chip Number   47
          OUTPUT OF DELAY CHIP   47  IS   2.00
          IT HAS A DELAYOF   0  CLOCK CYCLES
          OUTPUT OF CHIP   47  IS   2.00

       3. Chip Number  801
          OUTPUT OF DELAY CHIP  801  IS   2.00
          IT HAS A DELAYOF   0  CLOCK CYCLES
          OUTPUT OF CHIP  801  IS   2.00

       4. Chip Number  901
          OUTPUT OF DELAY CHIP  901  IS   2.00
          IT HAS A DELAYOF   0  CLOCK CYCLES
          OUTPUT OF CHIP  901  IS   2.00

       5. Chip Number  831
          OUTPUT OF DELAY CHIP  831  IS   2.00
          IT HAS A DELAYOF   1  CLOCK CYCLES
```

```
        OUTPUT OF CHIP  831  IS   2.00

    6. Chip Number  832
        OUTPUT OF DELAY CHIP  832  IS   2.00
        IT HAS A DELAYOF   1  CLOCK CYCLES
        OUTPUT OF CHIP  832  IS   2.00

    7. Chip Number  931
        OUTPUT OF DELAY CHIP  931  IS   2.00
        IT HAS A DELAYOF   1  CLOCK CYCLES
        OUTPUT OF CHIP  931  IS   2.00

    8. Chip Number  932
        OUTPUT OF DELAY CHIP  932  IS   2.00
        IT HAS A DELAYOF   1  CLOCK CYCLES
        OUTPUT OF CHIP  932  IS   2.00
```

//

```
Cycle  16 of snapshot  2 is ready to process
     8 elements will output data.
  These Chips are:
     1. Chip Number   46
        OUTPUT OF DELAY CHIP   46  IS   1.00
        IT HAS A DELAYOF   0  CLOCK CYCLES
        OUTPUT OF CHIP   46  IS   1.00

     2. Chip Number   47
        OUTPUT OF DELAY CHIP   47  IS   1.00
        IT HAS A DELAYOF   0  CLOCK CYCLES
        OUTPUT OF CHIP   47  IS   1.00

     3. Chip Number  801
        OUTPUT OF DELAY CHIP  801  IS   1.00
        IT HAS A DELAYOF   0  CLOCK CYCLES
        OUTPUT OF CHIP  801  IS   1.00

     4. Chip Number  901
        OUTPUT OF DELAY CHIP  901  IS   1.00
        IT HAS A DELAYOF   0  CLOCK CYCLES
        OUTPUT OF CHIP  901  IS   1.00

     5. Chip Number  831
        OUTPUT OF DELAY CHIP  831  IS   1.00
        IT HAS A DELAYOF   1  CLOCK CYCLES
        OUTPUT OF CHIP  831  IS   1.00

     6. Chip Number  832
        OUTPUT OF DELAY CHIP  832  IS   1.00
        IT HAS A DELAYOF   1  CLOCK CYCLES
        OUTPUT OF CHIP  832  IS   1.00

     7. Chip Number  931
        OUTPUT OF DELAY CHIP  931  IS   1.00
        IT HAS A DELAYOF   1  CLOCK CYCLES
        OUTPUT OF CHIP  931  IS   1.00

     8. Chip Number  932
        OUTPUT OF DELAY CHIP  932  IS   1.00
```

Appendix E

Associated Unitary Transformation Processor Emulation Files

GIV5.SS

```
CONFIGURATIN
     1     0   101    FLOT    DELY     32     0
     2     0   102    FLOT    DELY     32     0
     3     0   103    FLOT    DELY     32     0
     1     0   203    FLOT    DELY     32     0
     4     0   201    FLOT    DELY     32     0
     5     0   202    FLOT    DELY     32     0
     1     0   303    FLOT    DELY     32     0
     6     0   301    FLOT    DELY     32     0
     7     0   302    FLOT    DELY     32     0
   120     0   204    FLOT    DELY     32     0
   121     0   205    FLOT    DELY     32     0
   122     0   206    FLOT    DELY     32     0
   124     0   207    FLOT    DELY     32     0
   211     0   304    FLOT    DELY     32     0
   212     0   305    FLOT    DELY     32     0
   213     0   306    FLOT    DELY     32     0
   214     0   307    FLOT    DELY     32     0
     1     0   401    FLOT    DELY     32     0
   245     0   402    FLOT    DELY     32     0
   246     0   403    FLOT    DELY     32     0
     1     0   503    FLOT    DELY     32     0
   345     0   501    FLOT    DELY     32     0
   346     0   502    FLOT    DELY     32     0
   420     0   504    FLOT    DELY     32     0
   421     0   505    FLOT    DELY     32     0
   422     0   506    FLOT    DELY     32     0
   424     0   507    FLOT    DELY     32     0
     1     0   601    FLOT    DELY     32     0
   118     0   602    FLOT    DELY     32     0
   235     0   603    FLOT    DELY     32     0
   236     0   604    FLOT    DELY     32     0
   335     0   605    FLOT    DELY     32     0
   336     0   606    FLOT    DELY     32     0
   418     0   607    FLOT    DELY     32     0
   535     0   608    FLOT    DELY     32     0
   536     0   609    FLOT    DELY     32     0
     3     5    21
     1     0     4    FLOT    DELY     32     3
     2     0     5    FLOT    DELY     32     0
     3     0     6    FLOT    DELY     32     0
     5     0     7    FLOT    DELY     32     0
     6     0     8    FLOT    DELY     32     0
     5     0     9    FLOT    DELY     32     4
     6     0    10    FLOT    DELY     32     3
     5     7    11    FLOT    MULT     32     1
     6     8    12    FLOT    MULT     32     1
    10     0    13    FLOT    DELY     32     1
    11    12    14    FLOT    ADDR     32     1
    15     0    16    FLOT    DELY     32     0
    14    16    15    FLOT    ADDR     32     1
     4    10    17    FLOT    MULT     32     1
    15     0    18    FLOT    LOOK     32     1
    15     0    19    FLOT    DELY     32     1
     9    18    20    FLOT    MULT     32     1
    17    18    21    FLOT    MULT     32     1
    13    18    22    FLOT    MULT     32     1
    18    19    23    FLOT    MULT     32     1
    18    23    24    FLOT    MULT     32     1
     7     6    39
```

```
 1     0     8    FLOT    DELY    32     5
 2     0     9    FLOT    DELY    32     5
 3     0    10    FLOT    DELY    32     5
 4     0    11    FLOT    DELY    32     0
 5     0    12    FLOT    DELY    32     0
 6     0    13    FLOT    DELY    32     0
 7     0    14    FLOT    DELY    32     0
11     8    15    FLOT    MULT    32     0
13     9    16    FLOT    MULT    32     0
11     9    17    FLOT    MULT    32     0
12     8    18    FLOT    MULT    32     0
14    39    19    FLOT    MULT    32     0
14    40    20    FLOT    MULT    32     0
14     8    21    FLOT    MULT    32     1
14     9    22    FLOT    MULT    32     1
11    41    23    FLOT    MULT    32     1
12    42    24    FLOT    MULT    32     1
11    43    25    FLOT    MULT    32     1
13    44    26    FLOT    MULT    32     1
15    16    27    FLOT    ADDR    32     0
17    18    28    FLOT    ADDR    32     0
19     0    29    FLOT    DELY    32     0
20     0    30    FLOT    DELY    32     0
10    21    31    FLOT    MULT    32     1
22    10    32    FLOT    MULT    32     1
23    24    33    FLOT    ADDR    32     1
25    26    34    FLOT    ADDR    32     1
27    29    35    FLOT    ADDR    32     0
28    30    36    FLOT    ADDR    32     0
31    33    37    FLOT    ADDR    32     1
32    34    38    FLOT    ADDR    32     1
35     0    39    FLOT    DELY    32     0
36     0    40    FLOT    DELY    32     0
35     0    41    FLOT    DELY    32     1
36     0    42    FLOT    DELY    32     1
36     0    43    FLOT    DELY    32     1
35     0    44    FLOT    DELY    32     1
37     0    45    FLOT    DELY    32     2
38     0    46    FLOT    DELY    32     2
7     2    39
 1     0     8    FLOT    DELY    32     9
 2     0     9    FLOT    DELY    32     9
 3     0    10    FLOT    DELY    32     9
 4     0    11    FLOT    DELY    32     4
 5     0    12    FLOT    DELY    32     4
 6     0    13    FLOT    DELY    32     4
 7     0    14    FLOT    DELY    32     4
11     8    15    FLOT    MULT    32     0
13     9    16    FLOT    MULT    32     0
11     9    17    FLOT    MULT    32     0
12     8    18    FLOT    MULT    32     0
14    39    19    FLOT    MULT    32     0
14    40    20    FLOT    MULT    32     0
14     8    21    FLOT    MULT    32     1
14     9    22    FLOT    MULT    32     1
11    41    23    FLOT    MULT    32     1
12    42    24    FLOT    MULT    32     1
11    43    25    FLOT    MULT    32     1
13    44    26    FLOT    MULT    32     1
15    16    27    FLOT    ADDR    32     0
```

```
17   18   28   FLOT   ADDR   32   0
19    0   29   FLOT   DELY   32   0
20    0   30   FLOT   DELY   32   0
10   21   31   FLOT   MULT   32   1
22   10   32   FLOT   MULT   32   1
23   24   33   FLOT   ADDR   32   1
25   26   34   FLOT   ADDR   32   1
27   29   35   FLOT   ADDR   32   0
28   30   36   FLOT   ADDR   32   0
31   33   37   FLOT   ADDR   32   1
32   34   38   FLOT   ADDR   32   1
35    0   39   FLOT   DELY   32   0
36    0   40   FLOT   DELY   32   0
35    0   41   FLOT   DELY   32   1
36    0   42   FLOT   DELY   32   1
36    0   43   FLOT   DELY   32   1
35    0   44   FLOT   DELY   32   1
37    0   45   FLOT   DELY   32   2
38    0   46   FLOT   DELY   32   2
3     5   21
 1    0    4   FLOT   DELY   32   14
 2    0    5   FLOT   DELY   32   0
 3    0    6   FLOT   DELY   32   0
 5    0    7   FLOT   DELY   32   0
 6    0    8   FLOT   DELY   32   0
 5    0    9   FLOT   DELY   32   4
 6    0   10   FLOT   DELY   32   3
 5    7   11   FLOT   MULT   32   1
 6    8   12   FLOT   MULT   32   1
10    0   13   FLOT   DELY   32   1
11   12   14   FLOT   ADDR   32   1
15    0   16   FLOT   DELY   32   0
14   16   15   FLOT   ADDR   32   1
 4   10   17   FLOT   MULT   32   1
15    0   18   FLOT   LOOK   32   1
15    0   19   FLOT   DELY   32   1
 9   18   20   FLOT   MULT   32   1
17   18   21   FLOT   MULT   32   1
13   18   22   FLOT   MULT   32   1
18   19   23   FLOT   MULT   32   1
18   23   24   FLOT   MULT   32   1
7     2   39
 1    0    8   FLOT   DELY   32   1
 2    0    9   FLOT   DELY   32   1
 3    0   10   FLOT   DELY   32   16
 4    0   11   FLOT   DELY   32   0
 5    0   12   FLOT   DELY   32   0
 6    0   13   FLOT   DELY   32   0
 7    0   14   FLOT   DELY   32   0
11    8   15   FLOT   MULT   32   0
13    9   16   FLOT   MULT   32   0
11    9   17   FLOT   MULT   32   0
12    8   18   FLOT   MULT   32   0
14   39   19   FLOT   MULT   32   0
14   40   20   FLOT   MULT   32   0
14    8   21   FLOT   MULT   32   1
14    9   22   FLOT   MULT   32   1
11   41   23   FLOT   MULT   32   1
12   42   24   FLOT   MULT   32   1
11   43   25   FLOT   MULT   32   1
```

```
13   44   26   FLOT   MULT   32   1
15   16   27   FLOT   ADDR   32   0
17   18   28   FLOT   ADDR   32   0
19    0   29   FLOT   DELY   32   0
20    0   30   FLOT   DELY   32   0
10   21   31   FLOT   MULT   32   1
22   10   32   FLOT   MULT   32   1
23   24   33   FLOT   ADDR   32   1
25   26   34   FLOT   ADDR   32   1
27   29   35   FLOT   ADDR   32   0
28   30   36   FLOT   ADDR   32   0
31   33   37   FLOT   ADDR   32   1
32   34   38   FLOT   ADDR   32   1
35    0   39   FLOT   DELY   32   0
36    0   40   FLOT   DELY   32   0
35    0   41   FLOT   DELY   32   1
36    0   42   FLOT   DELY   32   1
36    0   43   FLOT   DELY   32   1
35    0   44   FLOT   DELY   32   1
37    0   45   FLOT   DELY   32   2
38    0   46   FLOT   DELY   32   2
9     4   26
 1    0   10   FLOT   DELY   32   19
 2    0   11   FLOT   DELY   32   16
 3    0   12   FLOT   DELY   32   11
 4    0   13   FLOT   DELY   32   11
 5    0   14   FLOT   DELY   32   10
 6    0   15   FLOT   DELY   32   10
 7    0   16   FLOT   DELY   32    2
 8    0   17   FLOT   DELY   32    1
 9    0   18   FLOT   DELY   32    1
10   12   19   FLOT   MULT   32    1
10   13   20   FLOT   MULT   32    1
13    0   21   FLOT   DELY   32    1
16   17   22   FLOT   MULT   32    1
16   18   23   FLOT   MULT   32    1
19   22   24   FLOT   MULT   32    1
21   23   25   FLOT   MULT   32    1
22   20   26   FLOT   MULT   32    1
19   23   27   FLOT   MULT   32    1
22    0   28   FLOT   DELY   32    4
23    0   29   FLOT   DELY   32    4
24   25   30   FLOT   ADDR   32    1
26   27   31   FLOT   ADDR   32    1
30   14   32   FLOT   ADDR   32    1
31   15   33   FLOT   ADDR   32    1
11   32   34   FLOT   MULT   32    1
11   33   35   FLOT   MULT   32    1
```

GIV5.TSF

```
EXPERIMENT
   4
  36
   6
     1     -1      1
     2    253      2
     3   -235      3
     4   -252      5
     5    234      6
     6      1      8
     7     -1      9
   116      0    113
   229      0    228
   230      0    229
   239      0    212
   240      0    213
   241      0    216
   242      0    217
   243      0    218
   244      0    219
   329      0    328
   330      0    329
   339      0    312
   340      0    313
   341      0    316
   342      0    317
   343      0    318
   344      0    319
   416      0    413
   529      0    528
   530      0    529
   539      0    512
   540      0    513
   541      0    516
   542      0    517
   543      0    518
   544      0    519
     1     -1      1
     2  -1106      2
     3   1035      3
     4   1107      5
     5  -1036      6
     6      0      8
     7      1      9
     1     -1      1
     2   -568      2
     3    534      3
     4    567      5
     5   -534      6
     6      0      8
     7     -1      9
     1     -1      1
     2    940      2
     3   -885      3
     4   -939      5
     5    884      6
     6      1      8
     7     -1      9
     1      0      0
```

GIVS.out

```
////////////////////////////////////////////////////////////

    Cycle  24 of snapshot  1 is ready to process
          2 elements will output data.
       These Chips are:
            1. Chip Number  625
                  4.618E-04*   834.     =  0.385
               OUTPUT OF CHIP  625  IS  0.385

            2. Chip Number  626
                  4.618E-04*   766.     =  0.354
               OUTPUT OF CHIP  626  IS  0.354

////////////////////////////////////////////////////////////

    Cycle  23 of snapshot  2 is ready to process
          2 elements will output data.
       These Chips are:
            1. Chip Number  623
                  -9.11    +   1.30    =  -7.81


    Cycle  22 of snapshot  3 is ready to process
          6 elements will output data.
       These Chips are:
            1. Chip Number  619
               OUTPUT OF DELAY CHIP  619  IS  0.385
               IT HAS A DELAYOF   4  CLOCK CYCLES
               OUTPUT OF CHIP  619  IS  0.385

            2. Chip Number  620
               OUTPUT OF DELAY CHIP  620  IS  0.354
               IT HAS A DELAYOF   4  CLOCK CYCLES
               OUTPUT OF CHIP  620  IS  0.354

            3. Chip Number  538
               OUTPUT OF DELAY CHIP  538  IS   1.37
               IT HAS A DELAYOF   2  CLOCK CYCLES
               OUTPUT OF CHIP  538  IS   1.37

            4. Chip Number  539
               OUTPUT OF DELAY CHIP  539  IS -2.071E-02
```

Appendix F

Interactive GADAR Single Element Receiver Emulation File

```
        Welcome to VAX/VMS V5.2

Username: SMITHR
Password:
        Welcome to VAX/VMS version V5.2 on node MISVX1
    Last interactive login on Friday, 22-DEC-1989 10:26Z>
@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@
 Lookup the phone number and office symbol of RADC personel, use the
 FIND command.
-------------------------------------------------------------------------------
 Send your MISVAX files to a LONEX printer, use the LP command.
-------------------------------------------------------------------------------
 To get information on special utilities installed on the 8650 cluster,
 type 'help @RADC' at the $ prompt.
/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/@/>
$ DIR

Directory DC$DISK2:[SMITHR]

BOTH.DIR;1          EMUL.DIR;1          GADAR.DIR;1         INFO.DIR;1
LOGIN.COM;4         LOGIN.COM;3         LOGIN.COM;2         LOGIN.JOU;1
SYSTEM.DIR;1

Total of 9 files.
$ SET DEF [SMITHR.GADAR]
$ DIR

Directory DC$DISK2:[SMITHR.GADAR]

COM.DIR;1           GADAR.EXE;1         GADTST.OUT;1        GADTST.SCF;1
GADTST.SSF;1        GADTST.TSF;1        SINGLE.SCF;1        SINGLE.SSF;1
SINGLE.TSF;1        SOURCE.DIR;1        SYSTEM.SCF;1        SYSTEM.SSF;1
SYSTEM.TSF;1        TER.OUT;1           TER.SCF;1           TER.SSF;1
TER.TSF;1           TEST.DIR;1

Total of 18 files.
$ RUN GADAR

    THIS IS THE GENERAL PURPOSE ADAPTIVE ARRAY PROGRAM GADAR.  GADAR IS
    CAPABLE OF SIMULATING A COMMUNICATION SYSTEM HAVING RECEIVING
    ELEMENTS IN SPACE EXCITED BY A SIMULATED SCENARIO.  THE SYSTEM IS
    SPECIFIED BY THE INTERCONNECTION OF STANDARD COMPONENT BUILDING
    BLOCKS INTERCONNECTED AT NODES.

    SYSTEM AND TEST RUN PARAMETERS ARE SPECIFIED BY THE USER IN AN
    INTERACTIVE DIALOG AND WRITTEN TO FILES.  THESE FILES ARE THEN USED
    TO SPECIFY SYSTEM CONFIGURATION AND TESTING MODE AT RUN TIME.

    THERE ARE THREE TYPES OF ANSWERS TO QUESTIONS USED IN THE
    INTERACTIVE PROGRAM CONSISTING OF YES AND NO, MENU SELECT, AND
    PARAMETER SPECIFICATION.  ALL USER COMMANDS MUST BE TERMINATED BY A
    CARRIAGE RETURN ('<CR>').

    THERE ARE SEVERAL COMMANDS THAT WILL BE VALID AT ANY TIME THAT A
    RESPONSE FROM YOU, THE USER, IS REQUIRED.  THESE COMMANDS CONSIST
    OF THE FOLLOWING:
         HELP-ADDITIONAL DETAILS ARE REQUESTED FOR QUESTION.
         EXIT-EXIT AFTER CLOSING FILES PRESENTLY BEING WRITTEN.
```

```
        BREAK-CLOSE FILES AND RETURN TO OPERATION SELECTION.

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW SCENARIO SPECIFICATION FILE.
         D   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         E   EXIT FROM GADAR
B

    WHAT IS THE NAME OF THE CONFIGURATIN SPECIFICATION FILE
    TO BE OPENED FOR WRITING?
SINREC.SSF

    WHAT COMPONENT TYPE WOULD YOU LIKE TO SELECT FOR COMPONENT   1?
         A   ANTENNA ELEMENT
         B   NOISE GENERATOR
         C   POWER DIVIDER
         D   TIME DELAY
         E   AMPLIFIER
         F   NODE CONVERSION FUNCTION
         G   ANALOG TO DIGITAL CONVERTER
         H   LOCAL OSCILLATOR
         I   PHASE SHIFTER (FIXED)
         J   MIXER
         K   SUMMING JUNCTION
         L   NONE ( TERMINATE ENTRY )
H

    Component number      1 is of type: LOSC
    What is the output node number for this component?
1

    What is the output level in dBm for the local oscillator of
    component number    1?
0.0

    What is the center frequency in kHz for the local oscillator of
    component number    1?
300000

    The following parameters have been specified for component    1
    of type LOSC.  Do you wish to change anything?(YES or NO)
         output node number:     1
         center frequency in kHz:      300000.000
         output level in dBm:      0.000
NO

    WHAT COMPONENT TYPE WOULD YOU LIKE TO SELECT FOR COMPONENT   2?
         A   ANTENNA ELEMENT
         B   NOISE GENERATOR
         C   POWER DIVIDER
         D   TIME DELAY
         E   AMPLIFIER
         F   NODE CONVERSION FUNCTION
         G   ANALOG TO DIGITAL CONVERTER
         H   LOCAL OSCILLATOR
         I   PHASE SHIFTER (FIXED)
         J   MIXER
         K   SUMMING JUNCTION
```

```
          L   NONE ( TERMINATE ENTRY )
C

     Component number      2 is of type: POWD
     What is the input node number for this component?
1

     Component number      2 is of type: POWD
     How many output nodes are there on this component?
2

     What are the output node numbers for this component?
2,3

     The following parameters have been specified for component     2
     of type POWD.  Do you wish to change anything?(YES or NO)
          number of output nodes:     2
          input node number:     1
          output node number:     2
          output node number:     3
NO

     WHAT COMPONENT TYPE WOULD YOU LIKE TO SELECT FOR COMPONENT    3?
          A   ANTENNA ELEMENT
          B   NOISE GENERATOR
          C   POWER DIVIDER
          D   TIME DELAY
          E   AMPLIFIER
          F   NODE CONVERSION FUNCTION
          G   ANALOG TO DIGITAL CONVERTER
          H   LOCAL OSCILLATOR
          I   PHASE SHIFTER (FIXED)
          J   MIXER
          K   SUMMING JUNCTION
          L   NONE ( TERMINATE ENTRY )
I

     Component number      3 is of type: PHSF
     What is the input node number for this component?
3

     What is the output node number for this component?
4

     What is the phase shift in degrees for the phase shifter of
     component number     3?
90.0

     The following parameters have been specified for component     3
     of type PHSF.  Do you wish to change anything?(YES or NO)
          input node number:     3
          output node number:     4
          phase shift in degrees:     90.000
NO

     WHAT COMPONENT TYPE WOULD YOU LIKE TO SELECT FOR COMPONENT    4?
          A   ANTENNA ELEMENT
          B   NOISE GENERATOR
          C   POWER DIVIDER
          D   TIME DELAY
```

```
          E   AMPLIFIER
          F   NODE CONVERSION FUNCTION
          G   ANALOG TO DIGITAL CONVERTER
          H   LOCAL OSCILLATOR
          I   PHASE SHIFTER (FIXED)
          J   MIXER
          K   SUMMING JUNCTION
          L   NONE ( TERMINATE ENTRY )
F

     Component number      4 is of type: NDCN
     What is the input node number for this component?
2

     What is the output node number for this component?
5

     The following parameters have been specified for component     4
     of type NDCN.  Do you wish to change anything?(YES or NO)
          input node number:     2
          output node number:    5
NO

     WHAT COMPONENT TYPE WOULD YOU LIKE TO SELECT FOR COMPONENT    5?
          A   ANTENNA ELEMENT
          B   NOISE GENERATOR
          C   POWER DIVIDER
          D   TIME DELAY
          E   AMPLIFIER
          F   NODE CONVERSION FUNCTION
          G   ANALOG TO DIGITAL CONVERTER
          H   LOCAL OSCILLATOR
          I   PHASE SHIFTER (FIXED)
          J   MIXER
          K   SUMMING JUNCTION
          L   NONE ( TERMINATE ENTRY )
F

     Component number      5 is of type: NDCN
     What is the input node number for this component?
4

     What is the output node number for this component?
6

     The following parameters have been specified for component     5
     of type NDCN.  Do you wish to change anything?(YES or NO)
          input node number:     4
          output node number:    6
NO

     WHAT COMPONENT TYPE WOULD YOU LIKE TO SELECT FOR COMPONENT    6?
          A   ANTENNA ELEMENT
          B   NOISE GENERATOR
          C   POWER DIVIDER
          D   TIME DELAY
          E   AMPLIFIER
          F   NODE CONVERSION FUNCTION
          G   ANALOG TO DIGITAL CONVERTER
          H   LOCAL OSCILLATOR
```

```
          I    PHASE SHIFTER (FIXED)
          J    MIXER
          K    SUMMING JUNCTION
          L    NONE ( TERMINATE ENTRY )
A

     Component number   6 is of type ELMN.
     What is the output node number for this component?
7

     What is the element type for this component?
          A)   omni
A

     What are the X,Y,Z coordinates in meters specifying the location
     of this element?
0.0,0.0,0.0

     What are the roll, pitch, and yaw angles in degrees of the
     element bearing relative to normal orientation as defined for
     the element?
0.0,0.0,0.0

     What is the gain of this element in dB?
0.0

     The following parameters have been specified for component    6
     of type ELMN.  Do you wish to change anything?(YES or NO)
          output node number:    7
          element type name:OMNI
          X,Y, and Z in meters:      0.000      0.000      0.000
          roll, pitch, and yaw in degrees:      0.000      0.000      0.000
          gain in dB:      0.000
NO

     WHAT COMPONENT TYPE WOULD YOU LIKE TO SELECT FOR COMPONENT   7?
          A    ANTENNA ELEMENT
          B    NOISE GENERATOR
          C    POWER DIVIDER
          D    TIME DELAY
          E    AMPLIFIER
          F    NODE CONVERSION FUNCTION
          G    ANALOG TO DIGITAL CONVERTER
          H    LOCAL OSCILLATOR
          I    PHASE SHIFTER (FIXED)
          J    MIXER
          K    SUMMING JUNCTION
          L    NONE ( TERMINATE ENTRY )
B

     Component number   7 is of type NOIS.
     What is the output node number for this component?
8

     What is the system noise figure in dB at the output of
     the noise generator of component number    7?
10.0

     The following parameters have been specified for component    7
     of type NOIS.  Do you wish to change anything?(YES or NO)
```

```
          output node number:     8
          noise figure at output in dB:          10.000
NO

     WHAT COMPONENT TYPE WOULD YOU LIKE TO SELECT FOR COMPONENT    8?
          A    ANTENNA ELEMENT
          B    NOISE GENERATOR
          C    POWER DIVIDER
          D    TIME DELAY
          E    AMPLIFIER
          F    NODE CONVERSION FUNCTION
          G    ANALOG TO DIGITAL CONVERTER
          H    LOCAL OSCILLATOR
          I    PHASE SHIFTER (FIXED)
          J    MIXER
          K    SUMMING JUNCTION
          L    NONE ( TERMINATE ENTRY )
K

     Component number      8 is of type: SMJC
     How many input nodes in this component?
2

     Component number      8 is of type: SMJC
     What are the input node numbers for this component?
7,8

     What is the output node number for this component?
9

     The following parameters have been specified for component     8
     of type SMJC.  Do you wish to change anything?(YES or NO)
          number of input nodes:     2
          output node number:     9
          input node number:     7
          input node number:     8
NO

     WHAT COMPONENT TYPE WOULD YOU LIKE TO SELECT FOR COMPONENT    9?
          A    ANTENNA ELEMENT
          B    NOISE GENERATOR
          C    POWER DIVIDER
          D    TIME DELAY
          E    AMPLIFIER
          F    NODE CONVERSION FUNCTION
          G    ANALOG TO DIGITAL CONVERTER
          H    LOCAL OSCILLATOR
          I    PHASE SHIFTER (FIXED)
          J    MIXER
          K    SUMMING JUNCTION
          L    NONE ( TERMINATE ENTRY )
E

     Component number      9 is of type: AMPL
     What is the input node number for this component?
9

     What is the output node number for this component?
10
```

```
    What is the gain in dB for the amplifier of component number    9?
40.0

    The following parameters have been specified for component    9
    of type AMPL.  Do you wish to change anything?(YES or NO)
         input node number:    9
         output node number:   10
         gain in dB:    40.000
NO

    WHAT COMPONENT TYPE WOULD YOU LIKE TO SELECT FOR COMPONENT  10?
         A   ANTENNA ELEMENT
         B   NOISE GENERATOR
         C   POWER DIVIDER
         D   TIME DELAY
         E   AMPLIFIER
         F   NODE CONVERSION FUNCTION
         G   ANALOG TO DIGITAL CONVERTER
         H   LOCAL OSCILLATOR
         I   PHASE SHIFTER (FIXED)
         J   MIXER
         K   SUMMING JUNCTION
         L   NONE ( TERMINATE ENTRY )
F

    Component number    10 is of type: NDCN
    What is the input node number for this component?
10

    What is the output node number for this component?
11

    The following parameters have been specified for component   10
    of type NDCN.  Do you wish to change anything?(YES or NO)
         input node number:   10
         output node number:   11
NO

    WHAT COMPONENT TYPE WOULD YOU LIKE TO SELECT FOR COMPONENT  11?
         A   ANTENNA ELEMENT
         B   NOISE GENERATOR
         C   POWER DIVIDER
         D   TIME DELAY
         E   AMPLIFIER
         F   NODE CONVERSION FUNCTION
         G   ANALOG TO DIGITAL CONVERTER
         H   LOCAL OSCILLATOR
         I   PHASE SHIFTER (FIXED)
         J   MIXER
         K   SUMMING JUNCTION
         L   NONE ( TERMINATE ENTRY )
C

    Component number    11 is of type: POWD
    What is the input node number for this component?
11

    Component number    11 is of type: POWD
    How many output nodes are there on this component?
2
```

```
    What are the output node numbers for this component?
12,13

    The following parameters have been specified for component   11
    of type POWD.  Do you wish to change anything?(YES or NO)
         number of output nodes:    2
         input node number:   11
         output node number:   12
         output node number:   13
NO

    WHAT COMPONENT TYPE WOULD YOU LIKE TO SELECT FOR COMPONENT  12?
         A   ANTENNA ELEMENT
         B   NOISE GENERATOR
         C   POWER DIVIDER
         D   TIME DELAY
         E   AMPLIFIER
         F   NODE CONVERSION FUNCTION
         G   ANALOG TO DIGITAL CONVERTER
         H   LOCAL OSCILLATOR
         I   PHASE SHIFTER (FIXED)
         J   MIXER
         K   SUMMING JUNCTION
         L   NONE ( TERMINATE ENTRY )
12  J

    Component number    12 is of type: MIXE
    What is the input node number for port R of this component?
12

    Component number    12 is of type: MIXE
    What is the input node number for port L of this component?
5

    What is the output node number for port I of this component?
14

    The following parameters have been specified for component   12
    of type MIXE.  Do you wish to change anything?(YES or NO)
         input node number port R:   12
         input node number port L:    5
         output node number port I:   14
NO

    WHAT COMPONENT TYPE WOULD YOU LIKE TO SELECT FOR COMPONENT  13?
         A   ANTENNA ELEMENT
         B   NOISE GENERATOR
         C   POWER DIVIDER
         D   TIME DELAY
         E   AMPLIFIER
         F   NODE CONVERSION FUNCTION
         G   ANALOG TO DIGITAL CONVERTER
         H   LOCAL OSCILLATOR
         I   PHASE SHIFTER (FIXED)
         J   MIXER
         K   SUMMING JUNCTION
         L   NONE ( TERMINATE ENTRY )
J
```

```
    Component number    13 is of type: MIXE
    What is the input node number for port R of this component?
13

    Component number    13 is of type: MIXE
    What is the input node number for port L of this component?
6

    What is the output node number for port I of this component?
15

    The following parameters have been specified for component   13
    of type MIXE.  Do you wish to change anything?(YES or NO)
         input node number port R:   13
         input node number port L:    6
         output node number port I:   15
NO

    WHAT COMPONENT TYPE WOULD YOU LIKE TO SELECT FOR COMPONENT  14?
         A   ANTENNA ELEMENT
         B   NOISE GENERATOR
         C   POWER DIVIDER
         D   TIME DELAY
         E   AMPLIFIER
         F   NODE CONVERSION FUNCTION
         G   ANALOG TO DIGITAL CONVERTER
         H   LOCAL OSCILLATOR
         I   PHASE SHIFTER (FIXED)
         J   MIXER
         K   SUMMING JUNCTION
         L   NONE ( TERMINATE ENTRY )
G

    Component number    14 is of type: ATDC
    What is the input node number for this component?
14

    What is the output node number for this component?
16

    How many bits precision does the analog to digital converter
    of component number    14 have available?
12

    What is the maximum voltage level input to the
    analog to digital converter of component number   14?
1.0

    What is the minimum voltage level input to the
    analog to digital converter of component number  14?
-1.0

    The following parameters have been specified for component   14
    of type ATDC.  Do you wish to change anything?(YES or NO)
         input node number:   14
         output node number:   16
         bits of precision:   12
         maximum input level (voltage):     1.000
         minimum input level (voltage):    -1.000
NO
```

```
    WHAT COMPONENT TYPE WOULD YOU LIKE TO SELECT FOR COMPONENT  15?
         A   ANTENNA ELEMENT
         B   NOISE GENERATOR
         C   POWER DIVIDER
         D   TIME DELAY
         E   AMPLIFIER
         F   NODE CONVERSION FUNCTION
         G   ANALOG TO DIGITAL CONVERTER
         H   LOCAL OSCILLATOR
         I   PHASE SHIFTER (FIXED)
         J   MIXER
         K   SUMMING JUNCTION
         L   NONE ( TERMINATE ENTRY )
G

    Component number    15 is of type: ATDC
    What is the input node number for this component?
15

    What is the output node number for this component?
17

    How many bits precision does the analog to digital converter
    of component number    15 have available?
12

    What is the maximum voltage level input to the
    analog to digital converter of component number   15?
1.0

    What is the minimum voltage level input to the
    analog to digital converter of component number  15?
-1.0

    The following parameters have been specified for component   15
    of type ATDC.  Do you wish to change anything?(YES or NO)
         input node number:   15
         output node number:   17
         bits of precision:   12
         maximum input level (voltage):     1.000
         minimum input level (voltage):    -1.000
NO

    WHAT COMPONENT TYPE WOULD YOU LIKE TO SELECT FOR COMPONENT  16?
         A   ANTENNA ELEMENT
         B   NOISE GENERATOR
         C   POWER DIVIDER
         D   TIME DELAY
         E   AMPLIFIER
         F   NODE CONVERSION FUNCTION
         G   ANALOG TO DIGITAL CONVERTER
         H   LOCAL OSCILLATOR
         I   PHASE SHIFTER (FIXED)
         J   MIXER
         K   SUMMING JUNCTION
         L   NONE ( TERMINATE ENTRY )
L

    AT THIS TIME, DO YOU WANT TO:
```

```
          A    MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
          B    GENERATE A NEW SYSTEM SPECIFICATION FILE.
          C    GENERATE A NEW SCENARIO SPECIFICATION FILE.
          D    GENERATE A NEW TEST RUN SPECIFICATION FILE.
          E    EXIT FROM GADAR
E
$ TYPE SINREC.SSF
ONFIGURATIN
    1      LOSC
    1 0.30000000E+06 0.00000000E+00
    2      POWD
    2     1
    2     3
    3      PHSF
    3     4 0.90000000E+02
    4      NDCN
    2     5
    5      NDCN
    4     6
    6      ELMN
    7      OMNI 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.0000
0000E+00 0.00000000E+00 0.00000000E+00
    7      NOIS
    8 0.10000000E+02 0.00000000E+00
    8      SMJC
    2     9
    7     8
    9      AMPL
    9    10 0.40000000E+02
   10      NDCN
   10    11
   11      POWD
    2    11
   12    13
   12      MIXE
   12     5    14
   13      MIXE
   13     6    15
   14      ATDC
   14    16    12 0.10000000E+01-0.10000000E+01
   15      ATDC
   15    17    12 0.10000000E+01-0.10000000E+01
$ RUN GADAR

     THIS IS THE GENERAL PURPOSE ADAPTIVE ARRAY PROGRAM GADAR.  GADAR IS
     CAPABLE  OF  SIMULATING  A  COMMUNICATION  SYSTEM  HAVING RECEIVING
     ELEMENTS IN SPACE EXCITED BY A SIMULATED SCENARIO.  THE  SYSTEM  IS
     SPECIFIED  BY  THE  INTERCONNECTION  OF STANDARD COMPONENT BUILDING
     BLOCKS INTERCONNECTED AT NODES.

     SYSTEM AND TEST RUN PARAMETERS ARE SPECIFIED  BY  THE  USER  IN  AN
     INTERACTIVE DIALOG AND WRITTEN TO FILES.  THESE FILES ARE THEN USED
     TO SPECIFY SYSTEM CONFIGURATION AND TESTING MODE AT RUN TIME.

     THERE  ARE  THREE  TYPES  OF  ANSWERS  TO  QUESTIONS  USED  IN  THE
     INTERACTIVE  PROGRAM  CONSISTING  OF  YES  AND NO, MENU SELECT, AND
     PARAMETER SPECIFICATION.  ALL USER COMMANDS MUST BE TERMINATED BY A
     CARRIAGE RETURN ('<CR>').

     THERE ARE SEVERAL COMMANDS THAT WILL BE VALID AT ANY  TIME  THAT  A
```

```
    RESPONSE FROM YOU, THE USER, IS REQUIRED.  THESE COMMANDS CONSIST
    OF THE FOLLOWING:
         HELP-ADDITIONAL DETAILS ARE REQUESTED FOR QUESTION.
         EXIT-EXIT AFTER CLOSING FILES PRESENTLY BEING WRITTEN.
         BREAK-CLOSE FILES AND RETURN TO OPERATION SELECTION.

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW SCENARIO SPECIFICATION FILE.
         D   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         E   EXIT FROM GADAR
C

    WHAT IS THE NAME OF THE SCENARIO     SPECIFICATION FILE
    TO BE OPENED FOR WRITING?
SINREC.SCF

    What type would you like to specify for source number     1?
         A   Signal in space
         B   None ( terminate entry )
A

    What type of modulation does signal number     1 have?
         A   Noise (flat across band)
A

    What are the azimuth (degrees), elevation (degrees) and range
    (kilometers) discribing the location of this signal relative to
    array center?
90.0,0.0,1.0

    What is the effective radiated power (dBm) of this signal in the
    direction of array center?
-45.0

    What is the center frequency of the signal in kHz?
300000

    What is the bandwidth of the signal in kHz?
50

    The following parameters have been given for source number     1 of
    type SGNL.  Do you want to change anything (YES or NO)?
         Modulation type:  NOIS.
         Azimuth:      90.000 degrees
         Elevation:     0.000 degrees
         Range:       1.000 kilometers
         Effective radiated power:     -45.000 dBm
         Center frequency:  300000.000 kHz
         Bandwidth:      50.000 kHz
NO

    What type would you like to specify for source number     2?
         A   Signal in space
         B   None ( terminate entry )
B

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
```

```
        B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
        C   GENERATE A NEW SCENARIO SPECIFICATION FILE.
        D   GENERATE A NEW TEST RUN SPECIFICATION FILE.
        E   EXIT FROM GADAR
E
$ TYPE SINREC.SCF
CENARIO
   1     SGNL
OIS 0.90000000E+02 0.00000000E+00 0.10000000E+01-0.45000000E+02
0.30000000E+06 0.50000000E+02
$ RUN GADAR

    THIS IS THE GENERAL PURPOSE ADAPTIVE ARRAY PROGRAM GADAR.  GADAR IS
    CAPABLE OF SIMULATING A COMMUNICATION SYSTEM HAVING RECEIVING
    ELEMENTS IN SPACE EXCITED BY A SIMULATED SCENARIO.  THE SYSTEM IS
    SPECIFIED BY THE INTERCONNECTION OF STANDARD COMPONENT BUILDING
    BLOCKS INTERCONNECTED AT NODES.

    SYSTEM AND TEST RUN PARAMETERS ARE SPECIFIED BY THE USER IN AN
    INTERACTIVE DIALOG AND WRITTEN TO FILES.  THESE FILES ARE THEN USED
    TO SPECIFY SYSTEM CONFIGURATION AND TESTING MODE AT RUN TIME.

    THERE ARE THREE TYPES OF ANSWERS TO QUESTIONS USED IN THE
    INTERACTIVE PROGRAM CONSISTING OF YES AND NO, MENU SELECT, AND
    PARAMETER SPECIFICATION.  ALL USER COMMANDS MUST BE TERMINATED BY A
    CARRIAGE RETURN ('<CR>').

    THERE ARE SEVERAL COMMANDS THAT WILL BE VALID AT ANY TIME THAT A
    RESPONSE FROM YOU, THE USER, IS REQUIRED.  THESE COMMANDS CONSIST
    OF THE FOLLOWING:
        HELP-ADDITIONAL DETAILS ARE REQUESTED FOR QUESTION.
        EXIT-EXIT AFTER CLOSING FILES PRESENTLY BEING WRITTEN.
        BREAK-CLOSE FILES AND RETURN TO OPERATION SELECTION.

    AT THIS TIME, DO YOU WANT TO:
        A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
        B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
        C   GENERATE A NEW SCENARIO SPECIFICATION FILE.
        D   GENERATE A NEW TEST RUN SPECIFICATION FILE.
        E   EXIT FROM GADAR
D

    WHAT IS THE NAME OF THE EXPERIMENT   SPECIFICATION FILE
    TO BE OPENED FOR WRITING?
SINREC.TSF

    How many spectral lines should be used to model the broadband
    sources?
1

    What are the system center frequency and bandwidth in kHz?
300000,50

    What is the total number of iterations that you desire to be
    processed during this run?
16

    How often (in sampling intervals) should outputs be written to
    file?
1
```

```
    How many system nodes are to be tracked and written to the output
    file?
2

    What are the node numbers to be output to file?
16,17

    These parameters have been given for the specification of this
    experiment.  Do you want to change anything?  (YES or NO)
         Center frequency:  300000.000 kHz
         System bandwidth:       50.000 kHz
         Number of spectral lines:       1 .
         Total number of time samples processed:      16 .
         Frequency of output:  every      1 samples
         The number of output nodes:       2 nodes
         output node:      16
         output node:      17
NO

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW SCENARIO SPECIFICATION FILE.
         D   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         E   EXIT FROM GADAR
E
$ TYPE SINREC.TSF
XPERIMENT
0.30000000E+06 0.50000000E+02          1         16          1          2         16
       17
$ RUN GADAR

    THIS IS THE GENERAL PURPOSE ADAPTIVE ARRAY PROGRAM GADAR.  GADAR IS
    CAPABLE OF SIMULATING A COMMUNICATION SYSTEM HAVING RECEIVING
    ELEMENTS IN SPACE EXCITED BY A SIMULATED SCENARIO.  THE SYSTEM IS
    SPECIFIED BY THE INTERCONNECTION OF STANDARD COMPONENT BUILDING
    BLOCKS INTERCONNECTED AT NODES.

    SYSTEM AND TEST RUN PARAMETERS ARE SPECIFIED BY THE USER IN AN
    INTERACTIVE DIALOG AND WRITTEN TO FILES.  THESE FILES ARE THEN USED
    TO SPECIFY SYSTEM CONFIGURATION AND TESTING MODE AT RUN TIME.

    THERE ARE THREE TYPES OF ANSWERS TO QUESTIONS USED IN THE
    INTERACTIVE PROGRAM CONSISTING OF YES AND NO, MENU SELECT, AND
    PARAMETER SPECIFICATION.  ALL USER COMMANDS MUST BE TERMINATED BY A
    CARRIAGE RETURN ('<CR>').

    THERE ARE SEVERAL COMMANDS THAT WILL BE VALID AT ANY TIME THAT A
    RESPONSE FROM YOU, THE USER, IS REQUIRED.  THESE COMMANDS CONSIST
    OF THE FOLLOWING:
         HELP-ADDITIONAL DETAILS ARE REQUESTED FOR QUESTION.
         EXIT-EXIT AFTER CLOSING FILES PRESENTLY BEING WRITTEN.
         BREAK-CLOSE FILES AND RETURN TO OPERATION SELECTION.

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW SCENARIO SPECIFICATION FILE.
         D   GENERATE A NEW TEST RUN SPECIFICATION FILE.
```

```
         E   EXIT FROM GADAR
A

    WHAT IS THE NAME OF THE EXPERIMENT   SPECIFICATION FILE
    TO BE OPENED FOR READING?
SINREC.TSF

    WHAT IS THE NAME OF THE SCENARIO     SPECIFICATION FILE
    TO BE OPENED FOR READING?
SINREC.SCF

    WHAT IS THE NAME OF THE CONFIGURATIN SPECIFICATION FILE
    TO BE OPENED FOR READING?
SINREC.SSF

    WHAT IS THE NAME OF THE GADAR OUT    SPECIFICATION FILE
    TO BE OPENED FOR WRITING?
SINREC.OUT

    AT THIS TIME, DO YOU WANT TO:
         A   MAKE A SIMULATION RUN USING PREVIOUSLY GENERATED FILES.
         B   GENERATE A NEW SYSTEM SPECIFICATION FILE.
         C   GENERATE A NEW SCENARIO SPECIFICATION FILE.
         D   GENERATE A NEW TEST RUN SPECIFICATION FILE.
         E   EXIT FROM GADAR
E
$ TYPE SINREC.OUT
ADAR OUT
        2
      -44         41
      197       -184
      101        -95
     -167        157
     -148        141
      123       -117
      183       -175
      -71         66
     -201        197
       17        -16
      204       -200
       41        -40
     -191        187
     -104         97
      166       -154
      153       -142
     -115        119
$ LOG
  SMITHR       logged out at 22-DEC-1989 13:04:00.64Connection closed by remote
```

Appendix G

Interactive GADAR Three Element Receiver File

```
        Welcome to VAX/VMS V5.2

Username: SMITHR
Password:
        Welcome to VAX/VMS version V5.2 on node MISVX1
    Last interactive login on Thursday, 21-DEC-1989 14:19Z>
*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*
 Lookup the phone number and office symbol of RADC personel, use the
 FIND command.
-------------------------------------------------------------------------------
 Send your MISVAX files to a LONEX printer, use the LP command.
-------------------------------------------------------------------------------
 To get information on special utilities installed on the 8650 cluster,
 type 'help @RADC' at the $ prompt.
/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/>
$ set def [smithr.gadar]
$ dir

Directory DC$DISK2:[SMITHR.GADAR]

COM.DIR;1           GADAR.EXE;1         GADTST.OUT;1        GADTST.SCF;1
GADTST.SSF;1        GADTST.TSF;1        SINGLE.SCF;1        SINGLE.SSF;1
SINGLE.TSF;1        SOURCE.DIR;1        SYSTEM.SCF;1        SYSTEM.SSF;1
SYSTEM.TSF;1        TER.OUT;1           TER.SCF;1           TER.SSF;1
TER.TSF;1           TEST.DIR;1

Total of 18 files.
$ type ter.*;*

DC$DISK2:[SMITHR.GADAR]TER.OUT;1

ADAR OUT
         6
       253       -235       -252        234        252       -234
     -1106       1035       1107      -1036      -1106       1034
      -568        534        567       -534       -568        535
       940       -885       -939        884        939       -884
       833       -795       -833        796        832       -795
      -694        663        693       -662       -693        662
     -1034        987       1033       -987      -1032        985
       401       -372       -402        374        402       -373
      1131      -1110      -1131       1110       1131      -1110
       -98         96         96        -94        -97         96
     -1151       1130       1151      -1129      -1150       1129
      -234        230        235       -231       -234        229
      1074      -1054      -1075       1055       1075      -1054
       590       -548       -589        547        589       -547
      -932        866        932       -866       -934        867
      -857        796        858       -797       -858        797
       651       -675       -649        673        650       -674

DC$DISK2:[SMITHR.GADAR]TER.SCF;1

CENARIO
   1     SGNL
OIS 0.00000000E+00 0.00000000E+00 0.10000000E+01-0.40000000E+02
0.30000000E+06 0.50000000E+02
```

```
DC$DISK2:[SMITHR.GADAR]TER.SSF;1

ONFIGURATIN
   1     LOSC
   1 0.30000000E+06 0.00000000E+00
   2     ELMN
   2     OMNI-0.50000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.0000
0000E+00 0.00000000E+00 0.00000000E+00
   3     NOIS
   3 0.10000000E+02 0.00000000E+00
   4     ELMN
   4     OMNI 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.0000
0000E+00 0.00000000E+00 0.00000000E+00
   5     NOIS
   5 0.10000000E+02 0.00000000E+00
   6     ELMN
   6     OMNI 0.50000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.0000
0000E+00 0.00000000E+00 0.00000000E+00
   7     NOIS
   7 0.10000000E+02 0.00000000E+00
   8     POWD
   2    1
   8    9
   9     SMJC
   2   10
   2    3
  10     SMJC
   2   11
   4    5
  11     SMJC
   2   12
   6    7
  12     PHSF
   9   13 0.90000000E+02
  13     AMPL
  10   14 0.50000000E+02
  14     AMPL
  11   15 0.50000000E+02
  15     AMPL
  12   16 0.50000000E+02
  16     NDCN
   8   17
  17     NDCN
  13   18
  18     NDCN
  14   19
  19     NDCN
  15   20
  20     NDCN
  16   21
  21     POWD
   2   19
  22   23
  22     POWD
   2   20
  24   25
  23     POWD
   2   21
  26   27
  24     MIXE
```

```
  22    17    28
  25      MIXE
  23    18    29
  26      MIXE
  24    17    30
  27      MIXE
  25    18    31
  28      MIXE
  26    17    32
  29      MIXE
  27    18    33
  30      ATDC
  28    34    12 0.10000000E+01-0.10000000E+01
  31      ATDC
  29    35    12 0.10000000E+01-0.10000000E+01
  32      ATDC
  30    36    12 0.10000000E+01-0.10000000E+01
  33      ATDC
  31    37    12 0.10000000E+01-0.10000000E+01
  34      ATDC
  32    38    12 0.10000000E+01-0.10000000E+01
  35      ATDC
  33    39    1? 0.10000000E+01-0.10000000E+01

DC$DISK2:[SMITHR.GADAR]TER.TSF;1

XPERIMENT
0.30000000E+06 0.50000000E+02          1         16          1          6         34
       35         36         37         38         39
$ log
  SMITHR       logged out at 21-DEC-1989 14:25:51.90Connection closed by remote ho
```

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